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WATER QUALITY CRITERIA DATA BOOK. VOLUME 3: EFFECTS OF CHEMICALS ON AQUATIC LIFE. SELECTED DATA FROM THE LITERATURE THROUGH 1968

Battelle Columbus Laboratories

Prepared for:

Environmental Protection Agency

May 1971

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Water Quality Criteria Data Book

Volume 3

Effects of Chemicals on Aquatic Life

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VIRONMENTAL PROTECTION AGENCY RESEARCH AND MONITORING

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16. Abstract

Original data from more than 500 technical publications concerning the specific effects of chemicals on individuals species of aquatic biota were collected and summarized in uniform format. Alphabetical assembly of the data by chemical allows rapid access to considerable detailed information. A species index facilitates search for information on the toxicity of chemicals to individual aquatic species. The details of major procedures in laboratory bioassay and field assessment of chemical toxicity in water are discussed. Freshwater and marine procedures are included. A total of [redacted] 961 references were utilized, ~~in preparing this report~~. Recommendations include: (1) establishment of an information-analysis center on chemical water pollution based to [redacted] some extent on the report prepared, (2) preparation of a listing of chemical constituents of effluents and continued up-dating of this list, (3) development of a pattern of [redacted] bioassays for evaluating the effects of a chemical on aquatic life (Data from these evaluations would be used in developing mathematical models for predicting chemical toxicity in a wide range of environmental circumstances,) (4) development of in situ bioassay procedures for more realistic assessment of chemical toxicity to aquatic life. (See also W72-08157 and W72-08158)

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EFFECTS OF CHEMICALS ON AQUATIC LIFE

Selected Data From the Literature Through 1968

by

Battelle's Columbus Laboratories

for the

ENVIRONMENTAL PROTECTION AGENCY

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EPA Review Notice

This report has been reviewed by the Environmental Protection Agency and approved for publication. The data are listed as reported in the literature without collaboration or evaluation of their validity. Therefore, these data must and cannot be used indiscriminately for the establishment of water quality criteria for the aquatic environment. These data should be used only as a guideline for the base of action. Approval does not signify that the contents necessarily reflect the views and policies of EPA, nor does mention of trade names or commercial products constitute endorsement or recommendation for use

ABSTRACT

Original data from more than 500 technical publications concerning the specific effects of chemicals on individual species of aquatic biota were collected and summarized in uniform format. Alphabetical assembly of the data by chemical allows rapid access to considerable detailed information. A Species Index facilitates search for information on the toxicity of chemicals to individual aquatic species.

The details of major procedures in laboratory bioassay and field assessment of chemical toxicity in water are discussed. Freshwater and marine procedures are included. A total of approximately 1000 references were utilized in preparing this report.

Recommendations include:

(1) Establishment of an information-analysis center on chemical water pollution based to some extent on the report prepared.

(2) Preparation of a listing of chemical constituents of effluents and continued up-dating of this list.

(3) Development of a pattern of bioassays for evaluating the effects of a chemical on aquatic life. Data from these evaluations would be used in developing mathematical models for predicting chemical toxicity in a wide range of environmental circumstances.

(4) Development of *in situ* bioassay procedures for more realistic assessment of chemical toxicity to aquatic life.

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SECTION I

INTRODUCTION

The internal and external chemical environment of an organism determines whether that organism will survive, grow, and perpetuate itself. Internal chemical balance is mediated by the genetic makeup of the organism, the external chemical milieu in which it lives, and all other environmental factors. The effect of chemicals on living organisms is an especially important factor in aquatic environs where organisms are in intimate contact with chemicals in solution and suspension. Water passes into and through the body of an organism primarily via the integument, membranes, gills, or mouth. Toxic chemicals in the water may cause immediate lethality although in many instances sublethal quantities of deleterious chemicals may be accumulated within the body. In time, the chemical residues in an organism may cause drastic effects of varying types, also including mortality. Complicating this situation is the effect of chemicals on lower animal forms which provide part or all of the food chain leading to higher aquatic organisms. Thus, sport fish may leave polluted areas not to avoid chemical pollutants or to escape death but rather to seek food, for example, when bottom fauna upon which they feed are obliterated. Low dissolved-oxygen concentrations in water caused by release of oxygen-consuming chemicals can also have equally drastic impact on aquatic organisms.

This then is the basic problem today in water pollution and is the primary subject of this report. A closely related problem, considering aquatic biota as indicators of chemical toxic effect, is the consideration of whether or not such water is safe for use by humans. At the moment fish bioassay appears to be the best method available for determining the toxic effect of chemicals on aquatic life.

In a report section entitled "Recommendations for the Use of Bioassays and Application Factors to Denote Safe Concentrations of Wastes in Receiving Streams", the National Technical Advisory Committee (Interim Report, 1967), has made the following recommendations in part for the use of bioassays:

> '1. For the determination of acute toxicities, flow-through bioassays are the first choice. Methods for carrying out these flow-through tests have been described by Surber and Thatcher, 1962; Lemke and Mount, 1963; Henderson and Pickering, 1963; Jackson and Brungs, 1966; Mount and Warner, 1963; Mount and Brungs, 1965; and Brungs and Mount, 1967. Flow-through bioassays should be used for unstable volatile or highly toxic wastes and those having an oxygen demand. They also must be used when several variables such as pH, DO, CO_2 and other factors must be controlled.
>
> 2. When flow-through tests are not feasible, tests of a different type or duration must be used. The kinds of local conditions affecting the procedure might be single application of pesticides or lack of materials and equipment.
>
> 3. Acute static bioassays with fish for the determination of TL_m values should be carried out in accordance with Standard Methods for the Examination of Water and Waste Water. Such tests should be used for the determination of TL_m values only for persistent, nonvolatile, highly soluble materials of low toxicity which do not have an oxygen demand as it is necessary to use the amount added as the concentration to which the test organisms are exposed.
>
> 4. When application factors are used with TL_m values to determine safe concentrations of a waste in a receiving water, the bioassay studies to determine TL_m values should

be made with the most sensitive local species and life stages of economic or ecological importance and with dilution water taken from the receiving stream above the waste outfall. In the absence of knowledge concerning the most sensitive of the important local species or life stages or due to difficulty in providing them in sufficient numbers, other species whose relative sensitivity is known can be used or tests may be carried out using one species of diatom, one species of an invertebrate and two species of fish, one of which should be a pan or game fish. Further, these bioassays must be performed with environmental conditions at levels at which the waste is most toxic. Tests should be repeated with one species at least monthly and when there are changes in the character or volume of the waste.

5. Concentration of materials with noncumulative toxic effects should not exceed 1/10 of the 96-hour TL_m value at any time or place. The 24-hour average of the concentration should not exceed 1/20 of the TL_m value. For toxicants with cumulative effects, the concentrations should not exceed 1/10 and 1/100 for the above respective values."

The need for water of better quality by improved pollution control has been chronicled broadly with considerable justification in news media, scientific journals, and government reports. The result of this attention has been the establishment of water quality criteria and federal requirements for states, localities, and consequently industries to set minimum water standards within certain time limits, and to enforce these standards. The basic Federal Water Pollution Control Act (1956) was provided and later amended in 1961, by the Water Quality Act of 1965, and by the Clean Water Restoration Act of 1966. In the years given, these amendments were approved as public laws. Water quality requirements are becoming more stringent each year. Carpenter (1968) has outlined federal policy and organization in regard to this problem. In Water Quality Criteria (1968), the various problems of water pollution control are discussed in detail and recommendations are made for measures to improve pollution management. Earlier, these and related problems were discussed in publications by the National Research Council (1966), the Department of Health, Education, and Welfare (Public Health Service Publication No. 999-WP-25, 1965), ORSANCO (Ohio River Valley Water Sanitation Commission, 1967), and the Environmental Pollution Panel (1965). Establishment of water quality criteria in the U.S. has been recently considered by the Aquatic Life Advisory Committee (1955, 1956, 1960), the American Society for Testing Materials (Katz and Woelke, 1967; Woelke, 1967), Bartsh and Ingram (1959, 1966), Carter (1968), Ettinger and Mount (1967), Okum (1968), Smith (1961), Tarzwell (1957, 1959, 1962), Weston (1964), and Wilhm and Dorris (1968). The Manufacturing Chemists Association (1967) listed the sources of information on water quality criteria. The number of meetings increases each year as announced in such periodicals as Water and Sewage Works. The problems of industrial water utilization and effluent management of chemical wastes are generally discussed by Bower (1965), Cairns (1965, 1967), in Public Works (Anonymous, 1968), and in various texts, as well as briefly in the section of this report entitled "Industrial Wastes". Engdahl and Croxton (1962) have discussed the economics of pollution, a matter further treated in such journals as Chemical Week and Chemical and Engineering News.

Eutrophication of lakes is a special pollution problem that is not discussed in this report. Excellent documents pertaining to eutrophication are by Fruh, et al (1966) and bibliographies by the U.S. Public Health Service (Mackenthun, 1962, 1965). Similarly, thermal effluents were not considered as a topic for this report, due primarily to the magnitude of research in this field. Useful, extensive bibliographies have been recently published, including ones by the American Society for Civil Engineering (1967), Kennedy and Mihurksy (1967), Raney and Menzel (1967), and Wurtz and Renn (1965).

Another special problem is pesticide contamination of the environment. This is discussed to a considerable extent throughout this report, but especially in the section "Field Assessments". Reviews or general references concerning the effect of pesticides in the environment or other agricultural problems of this nature include an article in Environmental Sciences and Technology (Anonymous, 1968); papers by Cottam (1961), Langer (1964), Moore (1967), and Robinson (1967); and periodicals such as Residue Reviews (Springer-Verlag New York Inc., Vol 1+, 1962+) and Pesticides Documentation Bulletin (U.S. Department of Agriculture, Vol 1+, 1965+).

Other useful reference sources on trends in water pollution control are the chemical industry trade journals, Chemical Week and Chemical and Engineering News, and such publications as the Conservation Foundation Letter, and the Environmental Health Letter (Vol 1+, 1961+).

This is something of the background in which this report was prepared in late 1968 and early 1969.

SECTION II

OBJECTIVES

The objectives of this program were to:

(1) Collect and summarize in standardized format the available information from the scientific literature concerning:

  (a) The specific effects of chemicals on individual species of aquatic biota. (This study was limited to studies of single chemicals or simple mixtures of chemicals and does not include industrial effluents that contain highly complex chemical mixtures.)

  (b) Details of the procedures and environmental factors important in the observation or the measurement of these effects.

(2) Review the existing information on aquatic life as it is applicable or related to the study of water pollution.

(3) Review the methodology used in studying the effects of chemicals on aquatic life.

SECTION III

LITERATURE SEARCH AND BIBLIOGRAPHIES

Some 3500 papers, mostly from the period 1950 through 1968, were screened and about 2000 obtained for direct examination. Foreign language publications were not included. About 500 contained original data, from which extracts were prepared (Appendices A and B). An attempt was made to be comprehensive for the years 1958 through 1968 with only selected references included preceding this period. Of these selected references, the majority were published after 1950, with only a few being from the older literature.

The primary source for identifying the references used in this study were the literature reviews published annually by the Water Pollution Control Federation Committee in the Journal of the Water Pollution Control Federation (1958-1968), which proved to be excellent. The reference list was checked against Chemical Abstracts, Biological Abstracts, Water Pollution Abstracts, and numerous recent special subject bibliographies. Very few additional references were added to the list from these other sources. Personal visits were made to selected governmental and industrial organizations to secure pertinent data. Information was also requested from the Science Information Exchange (Smithsonian Institution) and National Referral Center (Library of Congress). Letter requests for publications not commonly available were sent to a number of scientists in this field.

SECTION IV

FISH BIOASSAY

Fish bioassay of industrial wastes and other potentially toxic materials has evolved in the past 50 or so years from nonstandardized procedures by individual scientists to the present where standardized assay procedures now are available to researchers in this field. Early work on fish bioassays was done in Europe and Asia nearly 60 years ago. Pioneering work in the U.S. on developing procedures and methods for bioassay of fish was conducted by Shelford, Bilding, Carpenter, and Ellis. In 1945, Hart, Doudoroff, and Greenbank in a book now out of print described a standardized fish bioassay procedure, which Doudoroff, et al (1951) recommended as a standard method for use by industry, government agencies, and others. This method with comparatively few modifications, e.g., continuous flow exposure of fish in addition to static exposure, has been widely used and today is used more or less in its original form. The fish bioassay procedure outlined in the 12th edition of Standard Methods (American Public Health Association, 1967) is basically that described by Doudoroff, et al. Procedures developed by W. E. Martin of the Pesticides Regulation Division and by Burdick (1960) at the N.Y. Conservation Department are quite similar. A prepublication copy of fish bioassay procedures that is to appear in the forthcoming 13th edition of Standard Methods (1971) was kindly provided by Professor M. C. Rand. The following discussions are based primarily on this document.

Static Bioassay

Briefly, the static bioassay procedure can be described as follows:

(1) After determination of an approximate toxic range of a chemical or effluent, appropriate concentrations are prepared on a logarithmic or geometric scale within the toxic range.

(2) Small (5.0-7.5 cm) fish, which have been quarantined 10-30 days (min-max) to assure no disease problems and acclimatized to the chosen assay water, are placed in the chemical or effluent solutions prepared with dissolved oxygen in concentrations not less than 4 mg/l (warm water fish) and 5 mg/l (cold water fish) at a constant temperature. Temperatures of 25 ± 2 C and 15 ± 2 C are recommended for warm water and cold water species, respectively.

(3) Observation and recording are made of dead fish which should be removed at 8, 24, 48, and 96 hours after the assay is initiated. Notation of other effects, such as intoxication, distress, loss of equilibrium, and other abnormal behavior, should also be made.

(4) Calculation or estimation of a TL_{50} or TL_m for various time periods is made by interpolation of the data plotted on semilogarithmic coordinate paper.

The TL_m of a compound is not considered as representing the concentration of a chemical or effluent that is safe in fish habitats. It is merely a relative measure of the acute, lethal toxicity of the material to a certain fish under controlled environmental conditions and must be used with a mathematical application factor to determine safe concentrations of effluents to be released. This has been discussed by Doudoroff (1951), Warren and Doudoroff (1958), and the National Technical Advisory Committee (1967).

A further distinction between LD_{50}, LC_{50}, and EC_{50} is made in the prepublication copy of Standard Methods as follows:

> "The expressions 'lethal dose' (LD) and 'lethal concentration' (LC) have also been frequently used, the term 'lethal dose' often incorrectly. The expression 'lethal dose' is not appropriate when designating a certain concentration in an external medium, inasmuch as a dose, strictly speaking, is a measured quantity administered. Unlike 'lethal dose' and 'lethal concentration', the term 'tolerance limit' is universally applicable in designating a level of any measurable lethal agent, including high and low temperatures, pH, and the like. The expression 'effective concentration' (EC) applies to concentrations only and is generally used in connection with effects other than death."

The APHA procedure describes in excellent detail the selection and preparation of fish and diluent water, effluent samplings or preparation-dilution of test substances, use of aeration controls, etc.

Static, acute fish bioassay has been shown to be inadequate for estimating the effect of chemicals on fish. Lack of reproducibility between laboratories is the rule rather than the exception. Reasons for this include chemical and microbiological degradation of toxic compounds, volatility of some compounds, utilization of oxygen by microorganisms as well as by fish, water quality variability, accumulation of fish metabolic by-products in assay containers, and uptake of toxicants by the test animals.

Periodic (daily or more often) renewal of test solutions is a variation of the static, acute fish bioassay that can be utilized to overcome some of the objections of this type of evaluation. Continuous test solution renewal must be used in long-term, chronic exposures of fish to chemical solutions where sublethal effects are to be studied. This variation is recommended in the Standard Method especially "when there is evidence or expectation of a rapid change of toxicity of the test solution".

Also recommended in the procedure is the determination of temperature, DO, and pH of the samples under evaluation at various times during the experiment as well as of the chemical properties or dissolved mineral content of the diluent water. To quote, "A rather complete mineral analysis of the water is advisable". Furthermore, chemical analysis for the toxicant under study is suggested throughout the exposure period. Seldom is this type of information reported in the literature as is shown and discussed in subsequent sections of this report.

The U.S. Fish and Wildlife Service, Circular 185 (1964) describes static bioassay procedures in relation to piscicide studies being carried out by the U.S. Bureau of Sport Fisheries and Wildlife. Freeman (1953) discussed use of standardized diluent water in static bioassay of fish and aquatic invertebrates. Other authors have also discussed or used synthetic or defined water for bioassays (Cairns and Scheier, 1955, 1958, 1963, 1968; Doudoroff, 1956; Dowden and Bennett, 1965; Fitzgerald et al, 1952; Trama, 1955; and Whitley, 1968). Handling and maintenance of bioassay fish was described by Hunn, et al (1968). A number of authors have discussed mathematical treatment of fish toxicity data including Burdick (1957) and Henderson and Tarzwell (1957). Excellent general discussions of static fish bioassays have been published by Burdick (1960, 1967), Cairns (1957, 1966), McCall (1961), Tarzwell (1959), Wuhrmann and Woker (1959), and Wuhrman (1955).

Cope (1961) suggested standards for reporting fish toxicity tests which apparently have not been accepted widely. Essentially his appeal dealt with correct identification, size, and condition of the test fish; complete description of the procedure involved and of chemical, physical, and biological factors; volume of water and number of fish for that volume; etc. Many of these data are lacking in most of the papers reviewed in the present report.

Continuous Flow Bioassay

The majority of the factors discussed under static bioassay apply to the continuous flow procedure with the added requirement of automatic intermittent or continual metering of the test substance dissolved or suspended in diluent water into the test chambers and continuous flow-through of water. Problems associated with dissolved oxygen and test chemical content in static exposures can be obviated in the continuous flow technique since the water added contains these materials in constant concentrations.

Briefly, a continuous flow system is composed of:

(1) Diluent water reservoir from which water flows into the

(2) Constant head diluent supply where the water is cooled or heated to the desired temperature and then metered along with

(3) The effluent or toxicant (added with a chemical pump, Mariotte bottle, etc.) into

(4) The test container in which fish are exposed, and which

(5) Overflows into an appropriate drain.

An acclimatizing tank for test fish can also receive water from the reservoir and constant head diluent supply. Water flow is by gravity and the recommended flow rate is equal to a complete volume change of test containers in 6 hours.

Data are taken usually over a 5-day period and plotted as for the static bioassay. Five-day supplies of water and toxicant are required.

The procedure as it is outlined allows ample latitude for assembling the apparatus according to individual requirements. As guides, the work of Jackson and Brungs (1966), Surber and Thatcher (1963), Lemke and Mount (1963), Mount and Warner (1965), and Mount and Brungs (1967), and others are referred to. These reports deal in part with information concerning valve control systems, chemical metering pumps, serial dilution apparatus, and the proportional diluter as utilized in various types of studies.

The earliest paper found on continuous flow bioassay was by Merkens (1957), a British scientist, who devised an automatically controlled apparatus for monitoring and adjusting temperature, pH, dissolved oxygen, and toxicant concentration in the test water added. This system was ingenious for its time.

Alabaster and Abram (1965) have more recently described British continuous flow techniques. Flow rate is adjusted to maintain an adequate level of dissolved oxygen. The apparatus and treatment of data are described in considerable detail.

Other recent procedures or innovations on the continuous flow technique have been reported by Betts, et al (1967), Burke and Ferguson (1968), Grenier (1960), Hendersen and Pickering (1963), and Solon, et al (1968).

The use of the continuous flow procedure in chronic exposures (Mount, 1962, 1968; Mount and Stephan, 1967), piscicide development (Parker and Wurth, 1965), residue accumulation (Holden, 1966), tracer studies (Holden, 1962), spawning (Mount and Stephan, 1967), and avoidance (Foster, 1967; and Warner et al, 1966) is discussed in other sections of this report.

Burdick (1960, 1967) and Jackson and Brungs (1966) have thoroughly discussed the continuous flow technique and its applicability to current water pollution problems. There can be no doubt that continuous flow fish bioassay simulates the field situation more closely than does static bioassay.

Fish Selection

The selection of fish for bioassay depends in part on the species of appropriate size available for study that can be maintained in the laboratory and also on the native fish present in the receiving water under study. Lennon (1967) has recommended development of inbred strains of test fish for standard reference in much the same manner as inbred mouse strains are used in mammalian toxicology. Cope (1966) has also made similar recommendations.

Small, preferably juvenile, fish are generally used so that sufficient numbers may be accommodated in the laboratory. Mount (1968) has briefly listed fish species that might be used as appropriate test organisms. This listing was prepared at the National Water Quality Laboratory, Duluth, Minnesota. The fish were selected on the basis of the following criteria:

(1) Sport, commercial or forage value
(2) Potential for exposure to pollution
(3) Geographical distribution and abundance
(4) Suitability for laboratory studies
(5) Existing knowledge in regard to toxicity.

The fish selected were:

Primary list – all pollutants
  Threadfin shad *(Dorosoma petenense)*
  Brook trout *(Salvelinus fontinalis)*
  Rainbow trout *(Salmo gairdneri)*
  Northern pike *(Esox lucius)*
  Emerald shiner *(Notropis atherinoides)*
  Fathead minnow *(Pimephales promelas)*
  White sucker *(Catostomus commersoni)*
  Channel catfish *(Ictalurus punctatus)*
  White bass *(Roccus chrysops)*
  Bluegill *(Lepomis macrochirus)*

Largemouth bass *(Micropterus salmoides)*
Yellow perch *(Perca flavescens)*

Special list – for selected pollutants
Coho salmon *(Oncorhynchus kisutch)*
Lake trout *(Salvelinus namaycush)*
Mountain whitefish *(Prosopium williamsoni)*
American smelt *(Osmerus mordax)*
Smallmouth bass *(Micropterus dolomieui)*
Walleye *(Stizostedion vitreum)*

The goldfish *(Carassius auratus)* was the selected equivalent of the "white rat".

Hunn, et al (1968) list the bioassay species used by the Bureau of Sport Fisheries and Wildlife as follows:

Rainbow trout *(Salmo gairdneri)*
Brown trout *(Salmo trutta)*
Brook trout *(Salvelinus fontinalis)*
Lake trout *(Salvelinus namaycush)*
Northern pike *(Esox lucius)*
Goldfish *(Carassius auratus)*
Carp *(Cyprinus carpio)*
Fathead minnow *(Pimephales promelas)*
White sucker *(Catostomus commersoni)*
Black bullhead *(Ictalurus melas)*
Channel catfish *(Ictalurus punctatus)*
Green sunfish *(Lepomis cyanellus)*
Bluegill *(Lepomis macrochirus)*
Smallmouth bass *(Micropterus dolomieui)*
Largemouth bass *(Micropterus salmoides)*
Yellow perch *(Perca flavescens)*
Walleye *(Stizostedion vitreum)*

Henderson and Pickering (1963) state that many species are suitable for bioassays, including:

Guppy *(Lebistes reticulatus)*
Mosquito fish *(Gambusia affinis)*
Goldfish *(Carassius auratus)*
Fathead minnow *(Pimephales promelas)*
Bluegill *(Lepomis macrochirus)*

On the basis of research usage as determined by the papers reviewed in the present study, an even wider variety of fish has been used experimentally. These, along with their frequency of use and type of water in which they may be found, are summarized in Table 1. Only those found in more than one paper are listed.

Chronic Bioassay

Evaluation of sublethal concentrations of various chemicals in long-term fish exposures is probably the most reliable bioassay method for determining safe levels at which chemicals may be released into receiving water. The exposure may be either static in which periodic solution renewal is required or continuous flow in which the concentration of the chemical is maintained at a constant level. The latter is by far the method of choice. Both procedures have been discussed in previous sections.

Chronic Static Exposure

A few recent papers serve to illustrate the variations that may be employed in conducting this type of exposure. The long-term effect of a 2-hour exposure to Dieldrin on the reproduction of guppies *(Lebistes reticulatus)* was studied by Hubble and Reiff (1967) over a 12-month period. The fish were placed in a standardized water following the exposure. No harmful effect on reproduction was observed.

Weiss and Gakstatter (1964) studied the long-term effect of various pesticides on acetylcholinesterase activity of bluegill, golden shiner, and goldfish by daily replenishing the test solutions over periods up to 30 days. The pesticides studied could be detected at concentration levels down to 0.1×10^{-3} mg/l.

Test water containing subacute concentrations of copper or zinc was used by Grande (1967) to expose trout eggs, fry, and fingerlings. The test solutions were renewed during 28-day periods every second day in experiments with eggs and daily for young trout.

The effect of sublethal concentrations of Dieldrin on laboratory populations of guppies *(Poecilia reticulata)* in aquaria was studied by Cairns, et al (1967). Weekly renewal of test solutions over a 14-month period was employed.

Dugan (1967) studied the combined effects of sublethal concentrations of detergents and pesticides on goldfish. The test water was cleaned by filtering periodically and the chemical concentrations adjusted to desired levels. Four-month exposure periods to the surfactants and up to 51-day exposure periods to Dieldrin were studied. Synthetic water and 100-gal epoxy-coated, galvanized water tanks were used.

In a study of the effect of Diquat on bluegill and bluegill food organisms, Gilderhus (1967) exposed the animals to the chemical during a 24-week period with varied frequencies of sublethal concentrations.

None of these authors used the static, acute fish bioassay procedure outlined in Standard Methods.

TABLE 1. FISH USED IN BIOASSAYS, FREQUENCY OF USE, AND TYPE OF WATER IN WHICH THEY OCCUR

(Freshwater = F; Marine – Atlantic = A, Pacific = P)

Scientific Name	Common Name	Occurrence
Abramis brama	Bream	F
Ambloplites rupestris	Rock bass	F
Ameiurus nebulosus	Brown bullhead	F
Brachydanio rerio	Zebrafish	F
Campostoma anomalum	Stoneroller	F
*Carassius auratus**	Goldfish	F
C. carassius	European carp	F
*Catastomus commersoni**	White sucker	F
Cyprinodon variegatus	Longnose killifish	A
*Cyprinus carpio**	Carp	F
Ericymba buccata	Silverjaw minnow	F
Esox lucius	Northern pike	F
Eucalia inconstans	Brook stickleback	F
Fundulus similis	Striped mullet	A
*Gambusia affinis**	Mosquitofish	A-F
*Gasterosteus aculeatus**	Threespine stickleback	A-F-P
Gobio gobio	Gobie	F
Hyborhynchus notatus	Bluntnose minnow	F
*Ictalurus melas**	Black bullhead	F
*I. natalis**	Yellow bullhead	F
*I. nebulosus**	Brown bullhead	F
*I. punctatus**	Channel catfish	F
Lagodon rhomboides	Pinfish	A
*Lebistes reticulatus**	Guppy	F
Leiostomus xanthurus	Spot	A
Lepomis auritus	Redbreast sunfish	F
*L. cyanellus**	Green sunfish	F
*L. gibbosus**	Pumpkinseed	F
*L. macrochirus***	Bluegill	F
L. megalotis	Longear sunfish	F
*L. microlophus**	Redear sunfish	F
*Micropterus dolomieui**	Smallmouth bass	F
*M. salmoides**	Largemouth bass	F
Mugil cephalus	Striped mullet	A
*Notemigonus crysoleucas**	Golden shiner	F
Notropis atherinoides	Emerald shiner	F
N. cornutus	Common shiner	F
N. hudsonius	Spottail shiner	F
N. lutrensis	Red shiner	F
N. stramineus	Sand shiner	F
N. umbratilis	Redfin shiner	F
*Oncorhyncus kisutch**	Coho salmon	P-F
*O. tshawytscha**	Chinook salmon	P-F
*Perca flavescens**	Yellow perch	F
*Petromyzon marinus**	Sea lamprey	A-F
*Phoxinus phoxinus**	Red-sided shiner	F
*Pimephales notatus**	Bluntnose minnow	F
*P. promelas***	Fathead minnow	F
Rhinichthys atratulus	Blacknose dace	F
Rutilus rutilus	Roach	F
*Salmo gairdneri***	Rainbow trout	A-F-P
*S. salar**	Atlantic salmon	A-F
*S. trutta**	Brown trout	A-F
*Salvelinus fontinalis**	Brook trout	A-F
S. namaycush	Lake trout	F
*Semotilus atromaculatus**	Creek chub	F
*Stizostedion vitreum**	Walleye	F

All species listed were found in two or more papers.
*Found in more than 5 papers.
**The most commonly used species.

Chronic Continuous Flow Exposure

Brown, et al (1968), Butler (1965, 1967), Cairns and Scheier (1963), Cope (1965), Jensen and Gaufin (1966), Mount (1962, 1968), Mount and Stephan (1967), Olsen and Foster (1958), Raymont and Shields (1964), Surber and Thatcher (1963), and Weiss (1965) have utilized continuous flow techniques of their own creation for the study of a variety of aquatic organisms in long-term, continuous flow exposure to a variety of chemicals. Exposure periods up to 11 months were employed in these studies. The reports cited above represent less than 5 percent of the total number of papers from which data were extracted for Appendices A and B.

Generally, chemicals are toxic at lower concentrations in continuous flow exposures, especially long-term ones, than in static exposures. Furthermore, nonlethal effects occur more readily in continuous flow bioassays. For example, Mount (1968) reported for this type of bioassay that the "safe concentration" was 3-7 percent of the 96-hour TL_m (static exposure) in studying the chronic toxicity of copper to fathead minnows. Furthermore, Mount and Stephan (1967) have stated that the biologically safe concentrations for Malathion and butoxyethanol ester of 2,4-D as determined in a continuous flow, chronic study are 1/45 and 1/9, respectively, of the 96-hour TL_m for each of these compounds as determined in static bioassay. However, Cairns and Scheier (1963) found in a study of the acute and chronic effects of sodium alkyl benzene sulfonate on sunfish that results from the two types of exposure at equivalent concentrations of ABS were quite close although not identical.

As further requirements to improve water quality are imposed, the need for chronic continuous flow data concerning the effects of sublethal concentrations of potential pollutants on aquatic biota will increase.

In situ Bioassay

The need for standardizing fish bioassay laboratory procedures has led to environmental laboratory conditions unlike those found in streams and lakes. Factors such as fluctuating sunlight, temperature, DO, pH, pollutant and nutrient concentration, etc., cannot be taken into account or compensated for in the laboratory. *In situ* evaluation of a chemical solution in the stream or body of water in which it is to be released is a method of determining with an improved degree of accuracy the concentration effects of a discharge released into that particular body of water. Exposures to the chemical in question of native species of fish can be conducted by means of portable live cars, cages, plastic pools, or raceways. Thus, the fish species of concern for a given stream can be studied in conditions approaching their particular complex ecological situation.

There is no standard procedure for this type of bioassay, but it has been employed to some extent as briefly discussed later in the section, "Field Studies". Burdick (1967) has recommended this approach and pointed out that automated water quality monitoring equipment now available can provide continuous recording of physical and chemical changes in water conditions which may allow correlation of bioassay data with ecological conditions. Raceways with disposable vinyl liners are used in advanced evaluation of piscicides as well as 9-10-ft-diameter vinyl wading pools with bottom soils of various types, pond or ground waters, aquatic plants and invertebrates, fish, and amphibians, as required. Hawskley (1967) speculated on the advent of "continuous bioassay" in which effluent and receiving water in varied ratios will be circulated into and out of test containers and noted that this almost of necessity will have to be performed at the plant site. Standard method fish bioassays are conducted in this laboratory in conjunction with routine chemical analyses and analyses with an atomic absorption spectrophotometer. Hawkins stated that a mobile unit for conducting fish bioassays and chemical analyses at the plant site was in the design stage in 1964. A mobile bioassay unit was used in developing selective larvicides for control of sea lamprey (Howell and Marquette, 1963). Automatic water quality monitors can provide continuous and depth-profile data acquisition for water temperature, dissolved oxygen, pH, conductance, dissolved chlorides, oxidation-reduction potential, and turbidity. These parameters are indirect but excellent physical-chemical indicators of water pollution. In conjunction with fish bioassays, they can provide data suitable for mathematical modeling and simulation. More than 200 monitors of this type are now in operation in the United States. The monitor can be housed in a trailer for portability. Weather data recording for air temperature, solar radiation, wind speed and direction, and total precipitation can be integrated into the continuous recorder.

Fish Responses Other Than Bioassay Lethality

Methods for laboratory study of fish response to chemicals in freshwater environments vary nearly as much as the number of investigators in this field of research. These range from simple observations (as suggested in Standard Methods and other sources); to sophisticated determinations of chemical residues, ACHE blood content, etc.; to the highly sophisticated Conditioned Avoidance Response Apparatus (CARA). These methods are identified in Table 2. One of these procedures may become a "standard method" for aquatic laboratory studies, but this does not appear likely to occur in the near future. Standard static and continuous flow fish bioassay methods will probably remain the principal laboratory tools for developing toxicity data with chronic exposures becoming more widely used. Some of the methods, notably, the avoidance, life stage, fish tissue culture, and CARA techniques, may be very useful in determining more precisely the "safe concentration" levels for chemical effluent release. Texts, such as those by Brown (1957) describe physiological methods for studying fish. Some of these methods would be highly applicable to the study of the effect of chemicals on aquatic life and could form the basis for the development of new procedures.

TABLE 2. LABORATORY METHODS FOR STUDYING THE EFFECT OF CHEMICALS ON FISH OTHER THAN BIOASSAY LETHALITY

Type	Comments	References
Observations of abnormal behavior	Observations may be made on the following: Quiescence, excitability, or irritability Surfacing or sounding Tetanic or flaccid movement Swimming – erratic, convulsive, gyrating, inverted on side, etc. Changes in pigmentation External mucosa – exudate, shedding, etc. Integument hemorrhagia Rate of respiration – slow, irregular, gulping, etc. Gill hemorrhaging or mucous discharge Defecating or regurgitating mucous or other material Sensitivity to stimuli such as light, sound, touch, electric probe, etc. Moribundity – distended operculum, opaque eyes, etc. Recovery – complete, or not.	Brown, et al (1968), Cairns, et al (1967), Cope (1966), Fromm and Schiffman (1958), Grindley (1946), Mount (1962), and Olsen and Foster (1958)
Autopsy and histology	Tissue and organ pathology are studied by appropriate methods. Decrease of glycogen and RNA, tissue dissociation, necrosis, lesions, and secretions may also be noted.	Blumenkratz (1956), Cairns (1966), Cairns and Scheier (1963), Cope (1965), Eng. Science, Inc. (1964), Gilderhus (1967), Herbert and Shurben (1964), Mount (1964), Mount and Stephen (1967), Van Valin, et al (1968), and Warner, et al (1966)
Avoidance	Raceways or similar laboratory structures are generally used so that a chemical solution can be metered into the bioassay water to establish a concentration gradient. Fish have been trained to discriminate between very low concentrations of selected chemicals.	Cairns (1957), Costa (1965), Hasler and Wisby (1949), and Ishio (1965)
Growth retardation	Chronic exposure was the most effective technique utilized.	Crandall and Goodnight (1962), Olsen and Foster (1958), and Royer (1966)
Residue analysis	Following exposure, organs of the fish are removed and analyzed for specific chemical content. This technique is used most often in studies of pesticide accumulation, and is also quite useful in field studies to show previous exposure. Whole fish homogenates have also been analyzed as well as animal feeds and processed sea foods prepared from various types of marine fish species.	Butler (1965, 1967), Cope (1965), Eisler (1967), Gilderhus (1966, 1967), Godsil and Johnson (1968), Holden (1966), Mahdi (1956), Moubry, et al (1968), Mount (1962), Mount and Stephan (1967), Pagan and Hageman (1950), Ullman, et al (1961), Weiss (1965), and Welch and Spindler (1964)

TABLE 2. (Continued)

Type	Comments	References
Acetylcholinesterase (ACHE) activity of brain	This method is used primarily in the study of organophosphorus pesticides in both laboratory and field studies of freshwater and marine types. The utility of this method is somewhat limited because of its near specificity for organophosphates.	Butler (1965), Cope (1965), Fromm and Schiffman (1958), Weiss (1959, 1961, 1964, 1965), and Weiss and Gakstatter (1964)
Radiotracers	This technique is used primarily in the study of pesticides and metal ions where labelling can be successfully accomplished. Tissue and organ analyses of radiotracer accumulation have been conducted. Among the radioisotopes used in fish studies are Ca^{45}, C^{14}, P^{32}, and Zn^{35}. Acetates, chlorides, Bayer 22408, DDT, Dieldrin, Dimethoate, Lindane and Parathion are some of the compounds studied in this manner. Wet combustion of tissues and measurement of $C^{14}O_2$ release has also been employed.	Butler (1965), Douglas and Irwin (1963), Fujiya (1965), Gakstatter and Weiss (1967), Holden (1962), Joyner (1961), Marchetti (1965), Miller, et al (1966), and Schmidt and Weidhaas (1961)
Effects on various life stages of fish	Effects of chemicals on sperm, eggs, yearling, and adult fish as well as fry are often studied to determine the relative resistance of these life stages to chemicals. Embryos from fertilized eggs have also been studied with the finding that fertilized egg membranes provide some resistance to the effects of chemicals.	Cairns and Scheier (1959), Cope (1966), Crandall and Goodnight (1962), Goodman (1951), Grande (1967), Hiltibran (1967), Marchetti (1965), Mount (1968), Piavis (1962), and Skidmore (1966)
Spawning (reproductive behavior)	This may be studied in the laboratory by providing suitable objects, such as pieces of cement-asbestos tile; and proper environmental conditions, including a controlled photoperiod, for this activity. Spawning in several studies was shown to be affected by concentrations of chemical much lower than those for the TL_m (96 hr). A "Laboratory Fish Production Index" (LFPI) has been proposed and is gaining acceptance.	Cairns, et al (1967), Cohen, et al (1961), Gilderhus (1967), Holden (1966), Hubble and Reiff (1967), Mount (1962, 1968), and Mount and Stephan (1967)
Swimming or cruising speed and oxygen consumption while swimming	Specifically designed raceways, cages, or "current trays" are required to determine rate of speed. Oxygen utilization can be determined by means of an oxygen-consumption chamber or respirometer. This is a useful technique for studying fish larger than fry. Current velocity can be controlled and is an important factor in studying large fish which require sufficient speed for oxygen transfer in their gills.	Cairns and Scheier (1963), Doudoroff and Warren (1962), Herbert and Shurben (1963), Mount (1962), and Ogilvie and Anderson (1965)
Chemical resistance of fish	After sublethal exposure, fish acquire specific resistance to certain chemicals. This has been demonstrated in the laboratory and the field most frequently for pesticides and metals.	Boyd and Ferguson (1964), Darsie and Corriden (1959), Fairchild (1955), Ferguson, et al (1954, 1955), and Mount (1968)

TABLE 2. (Continued)

Type	Comments	References
Blood studies	Changes in erythrocyte count, hemoglobin, sodium and calcium levels, microhematocrit, and hematocrit have been used in a variety of studies. The latter has been suggested as a measure of the state of health of bioassay fish prior to testing.	Cairns and Scheier (1963), Cope (1965, 1966), Gilderhus (1967), Hatch (1957), and Hunn, et al (1968)
Glucose transport	This is an *in vitro* type of study using dissected fish gut.	Stokes and Fromm (1965)
Fish tissue culture	Epithelial cells of fathead minnow cultured on modified Eagle's MEM medium, were found to have a reduced mitotic index at the calculated "safe concentration" of zinc. It was concluded that one-tenth of the 96-hr TL_m is probably closer to the safe concentration.	Rachlin and Perlmutter (1968)
Environmental stress	Reduced DO or increased temperature caused increased toxicity of various chemicals.	Cairns (1957), Lloyd (1961), and Pickering (1968)
Thermal acclimatization	In studies of the effect of DDT on salmon, it was found that DDT interferes with the normal thermal acclimation mechanism. Fish exposed to 10 ppm DDT and acclimated to warm water were extremely sensitive to cold water. Acclimatization also affected chemical toxicity.	Cope (1963, Keenleyside (1958), and Greer and Paim (1968)
Fish taste	The taste of sport fish can be drastically changed by chemical pollutants.	Hynes (1966) and Rachlin and Perlmutter (1968)
Conditioned avoidance response apparatus (CARA)	Toxicant-induced behavior of fish exposed to sublethal concentrations of chemicals was studied in raceways by means of photographing the fish at various intervals and calculating response in terms of relative position. A large mirror facilitated photography. At concentration levels 1/2000 of the 96-hr TL_m value for tetraethyl pyrophosphate (TEPP), aberrant behavior of goldfish was noted. A ratio of 1/25 was obtained for Toxaphene.	Eng. Science, Inc. (1964) and Warner, et al (1966)

SECTION V

BIOASSAY OF AQUATIC ORGANISMS OTHER THAN FISH

Surprisingly few aquatic organisms other than fish have been used as test organisms in bioassays. The organisms most commonly used are numerous species of algae and the crustaceans, *Daphnia magna* and *D. pulex*. Other freshwater invertebrates used in bioassays include protozoa *(Paramecium* and *Tetrahymena)*, planaria *(Planaria* and *Dugesia)*, crustacea *(Gammarus)*, gastropods *(Lymnaea* and *Physa)*, stonefly and mayfly naiads, and caddisfly and midge larvae. Oysters and shrimp are the principal test animals other than fish in marine bioassays. The oyster *(Ostrea)* are quite sensitive to low concentrations of some chemicals as determined by retarded shell growth. The brown, pink, and white shrimp *(Penaeus)* are the most commonly used crustacea in seawater bioassays. Barnacles *(Balanus)* are also used. These are discussed in the section, Marine Bioassay. Table 3 is a listing of references using various organisms other than fish for freshwater bioassay studies.

Procedures developed by C. M. Palmer and T. E. Maloney (1955) at the Taft Engineering Center in Cincinnati, Ohio, and by G. P. Fitzgerald, et al (1952, 1958, 1963) are widely used for laboratory study of freshwater algae.

There are no generally accepted or standard procedures for bioassays using these other types of organisms, although the procedures developed by Bertil Anderson (1944, 1945, 1948, 1960) in his studies of *D. magna* are commonly used.

In evaluating papers from which data were extracted (Appendices A and B), it was evident that a much broader spectrum of species are studied in the field than under laboratory conditions.

TABLE 3. A PARTIAL LISTING OF REFERENCES USING FRESHWATER AQUATIC ORGANISMS OTHER THAN FISH FOR BIOASSAY

Type	References
Algae: *(Chlorella pyrenoidosa, Microcystis aeruginosa,* and numerous other species)	Abram (1967), Alabaster and Swain (1963), Beak (1958), Elson and Kerswill (1967), Ganelin, et al (1964), Holden (1964), Hopkins, et al (1966), Kallman, et al (1962), Kemp, et al (1966), Khan (1964), Merkens (1958), Nejedly (1967), Palmer and Maloney (1955), and Sprague, et al (1965)
Invertebrates: *(Daphnia magna, D. pulex, Gammarus pulex, Culex* spp, etc.)	Abram (1967), Anderson (1946), Burdick (1965), Cairns, et al (1965), Chadwick (1960), Clarke (1947), Fromm (1965), Gaufin (1961), Gaufin, et al (1961), Henderson, et al (1961), Ingols (1959), Kabler (1957), Naylor (1965), Shaw and Grushkin (1967), Sprague (1965), Tarzwell (1957), Tarzwell and Henderson (1960), Turnbull, et al (1954), Weiss and Botts (1957), Wilber (1965), Williams (1964), and Wood (1957)
Vertebrates: *(Rana pipiens, R. catesbieana, Bufo valliceps* – sperm, eggs, tadpoles, and adults)	Cairns, et al (1965), Lackey (1957), Shaw and Grushkin (1967), and Stroud (1967)

SECTION VI

BIOCHEMICAL OXYGEN DEMAND (BOD) AND RELATED MICROBIOLOGICAL PROCEDURES

Biochemical Oxygen Demand

The biochemical oxygen demand (BOD) test is a test which is designed to determine the relative oxygen requirement of a municipal and/or industrial effluent. The determination of BOD of an effluent for the purpose of regulating the rate of discharge into a stream or sewerage system with minimal adverse effects on the oxygen resources of the receiving water will be at best an analytical starting point. BOD has several very limiting criteria which must be adequately understood for this technique of possible waste dilution to be useful. The procedure for BOD determinations as described in the 13th Edition of the Standard Methods for the Examination of Water and Waste Water (American Public Health Association, 1967) provides the basis for this discussion. This procedure has been essentially the same for more than 10 years with comparatively minor changes.

Although basically a simple bioassay to execute, the exceptions and precautions given in the BOD procedure make it somewhat formidable to the uninitiated. Briefly without specific details, the procedure consists of:

(1) Microbial seeding (if needed) of appropriate water dilutions of the chemical or effluent and initial determination of the dissolved oxygen (DO) of the sample by the iodometric method, azide modification. Sample dilutions are prepared with distilled water saturated with dissolved oxygen and buffered at pH 7.2 with a phosphate buffer solution.

(2) Incubation of the seeded samples at 20 C for 5 days and in darkness in standard BOD bottles which are water-sealed to exclude oxygen.

(3) DO determination of the diluted samples after the 5-day incubation period. The most reliable results are said to be for that dilution which shows a residual DO of at least 1 mg/l and a depletion of at least 2 mg/l. For toxic chemicals or effluents, toxic effect is indicated by lack of oxygen utilization by the microorganisms. When the lag period for microbial growth is prolonged, incubation periods of up to 20 days or longer may be employed.

(4) When substances are evaluated that are oxidizable by molecular oxygen, then an immediate dissolved oxygen demand (IDOD) should be determined and taken into consideration when calculating the BOD. The IDOD is a short-term assay in which DO is determined 15 minutes after the sample is added to the dilution water.

Carbon compounds utilizable by aerobic microorganisms, oxidizable nitrogen compounds utilizable by nitrogen bacteria, and certain chemical reducing compounds (ferrous iron, sulfites, sulfides, and aldehydes) are the three main types of chemicals that influence oxygen demand. The latter can be taken into consideration by the IDOD determination. Solubility and volatility of chemicals must also be considered. Some organic wastes are not oxidizable and thus are not amenable to the BOD bioassay. When such wastes are suspected, chemical oxygen demand (COD) and total carbon (TC) analyses would be conducted for comparison with BOD results.

According to the procedure: "In many cases, particularly in food processing wastes, a satisfactory seed may be obtained by using the supernatant liquor from domestic sewage which has been stored at 20 C for 24-36 hr", but it goes on to state that "acclimated" seed and receiving water below a point (2-5 miles) of effluent discharge may be used since "many industrial wastes contain compounds which are not amenable to oxidation by domestic-sewage seed". If the concern is with dissolved oxygen depletion, then an "acclimated" seed would seem most appropriate whether it is acclimated in the laboratory or collected downstream from a discharge. If the concern is with the toxic level of an effluent, then both acclimated and domestic-sewage seed evaluations might be made to establish a type of index for safe discharge. In the event of evaluation of a new type of discharge, seed acclimated in the laboratory to that particular discharge undoubtedly would be most desirable.

In regard to the amount of seed to be added, it is stated that, "Only past experience can determine the actual amount of seed to be added per liter." It would be more precise to add exact amounts of seed, e.g., Zintgraff, et al (1968) added 0.5-2.0 mg/l of seed in their studies.

The BOD bioassay suffers as do most laboratory procedures from lack of correlation between laboratory results and those obtained in the field. The need for a standardized procedure is recognized, but many factors enter into the behavior of a chemical in the aquatic environment that cannot be taken into account in the laboratory. Some of these objectionable features are alluded to and briefly discussed in Standard Methods, but others are overlooked and should be considered in attempting to apply the results of BOD determinations. The principal uncontrolled variable in the BOD procedure is the nonstandardized microbial inoculum or acclimated microbial seed as the case may be. Briefly, other factors include:

(1) Temperature and pH – seldom is the aquatic environment at precisely one temperature or pH.

(2) Fluctuating solids and dissolved solids content in receiving water – these can greatly influence the effect of a chemical on aquatic biota.

(3) Algae – although BOD determinations are conducted in a dark incubator, algae can grow heterotrophically and utilize oxygen, as do bacteria and other microorganisms. Dead algal cells can also affect BOD. Wisniewski (1958) has discussed the effect of algae on BOD determinations and DO in streams.

(4) Protozoa – these are known to be present in domestic sewage seed, and according to Bhatla, et al (1965) protozoa are responsible for approximately 30 percent of the BOD exerted under normal seeding conditions in 5-day BOD tests.

(5) Total aquatic biomass – all plants and animals other than the ones discussed above significantly influence the effect of chemicals on the aquatic environment.

(6) Mixed nutrient substrates – these are the rule rather than the exception in receiving water.

(7) Mixed toxicants in sublethal concentrations already present in receiving water – this problem has received comparatively little attention as judged by reports in the literature. Exceptions in non-BOD studies are the pesticides where the effect or accumulation of mixtures of these compounds and their decomposition products on and in aquatic biota have been documented. Additive, antagonistic, or synergistic effects probably do occur.

(8) Photochemical oxidation by ultraviolet from sunlight.

(9) Mixing due to currents – the BOD laboratory assay is static and therefore no mixing occurs.

(10) Other factors briefly mentioned in various papers as important in oxygen depletion are reduction of nitrates, anaerobic microbial alteration of organic compounds, secondary oxygen uptake, and decomposition of chemical intermediates.

All of these factors should be recognized by the analyst who should take them into account when applying data from BOD determinations.

BOD can be utilized to advantage by an experienced researcher in determining the oxygen depletion potential or the effect on microorganisms of an effluent containing toxic chemicals. Both are important considerations in effluent management for minimal effect on receiving waters.

On studying the various papers concerned with reporting BOD data, it was found that a wide variety of methods for reporting the data are utilized. As examples, Ingols (1954, 1955, 1956) plotted BOD values to show oxygen depletion in percent of control BOD with increasing concentrations of mercuric chloride, copper, zinc, etc., in ppm. Oberton and Stack (1957) using acclimated seed in studying the BOD of acrolein, diethanolamine, and methyl vinyl ketone reported their results as observed BOD in percentage of theoretical oxygen demand plotted with days of incubation. Randall (1966) reports the effect of acclimated seed on the pesticides, Malathion and Parathion, in terms of net oxygen utilization and time in hours. In an article entitled "The BOD of Textile Chemicals, Updated List – 1966", the data presented on nearly 400 chemicals and commercial chemical products are given as percent of 5-day BOD (Anon., 1966). In another paper (Anon., 1958), data for mercuric chloride, sulfuric acid, formaldehyde, and phenol are presented as the median toxic concentration in mg/l, i.e., the concentration at which 50 percent inhibition of oxygen utilization occurred; Zintgraff, et al (1968) reported BOD data using acclimated and nonacclimated seed for potassium cyanide in molar concentrations plotted against oxygen uptake in ppm or with time in hours. Rudolfs, et al (1950) reviewed the literature in 1950 on toxic materials affecting sewage treatment processes, streams, and BOD determinations and made general statements concerning this subject but with scant tabular material.

Since such a variety of methods for presenting data are found in the BOD literature, no attempt has been made to summarize BOD results in this report. The reader is referred to the various articles cited for information pertinent to his own interests, and to the summaries of chemical data shown in Appendixes A and B.

Herman (1959) proposed a toxicity index based on BOD data. Depending on the BOD curves obtained (percent available oxygen utilized plotted against concentration in mg/l), a series of "toxigrams" (Types 1 through 5) were devised, which were:

Toxigram Type 1 – simple poisons (the curve drops at toxic concentrations)

Toxigram Type 2 – no effect (the "curve" is flat)

Toxigram Type 3 – immediate dissolved oxygen demand (IDOD) by reducing substances (the curve rises to 100 percent oxygen utilization at higher concentrations)

Toxigram Type 4 – oxygen demand at low concentrations, inhibition of oxygen utilization at relatively high concentrations (the curve rises at low concentrations and drops at toxic levels)

Toxigram Type 5 – same as Type 4 except that at still higher concentrations oxygen utilization rose to 100 percent again. The author noted that the rise in oxygen utilization was due probably to simple chemical oxygen demand.

By designating the median toxic concentration (TC_{50}) and indicating the appropriate toxigram type, a convenient index for characterizing that particular chemical was obtained.

Despite its disadvantages, i.e., slowness, lack of correlation between the lab and the receiving stream, empirical application, and lack of reproducibility between laboratories, the BOD bioassay or some variation of it can be a useful tool in pollution control. An effort should be made by those who depend on BOD determinations to arrive at a common method for reporting results and possibly to develop a toxigram index similar to that proposed by Herman (1959).

Data for 33 chemicals from Herman's study are summarized in Table 4. This index approach has not been widely adopted, but probably should be in view of the confusing data presentations revealed in the present critique. Herman pointed out that toxic concentrations other than the median, e.g., TC_{10}, TC_{25}, TC_{75}, etc., can be chosen to suit individual industrial needs for release of chemicals.

Correlations of BOD with other data have also been attempted with varying success as follows:

Chemical data on phenols, heavy metals, etc. (Lloyd and Jordan, 1964)

Respirometric methods (Vernimmen, et al, 1967; Montgomery, 1967)

Aquatic biota (Burlington, 1962)

Coliforms (Burlington, 1962)

Hynes (1959) has diagramatically depicted the effect of an organic effluent on a river by plotting the BOD rate from an effluent outfall downstream and its relationship to dissolved oxygen, salt, suspended solids, concentration of nitrogen (NH_4 and NO_3) and phosphate (PO_4), and populations of algae, bacteria, sewage fungi, *Cladophora,* Protozoa, Tubificidae, *Chironomus, Asellus,* and clean water fauna. These diagrams are quite general and Hynes pointed out that the detailed relationship of the various parameters plotted varies with the type of effluent.

Short-Term Oxygen Demand

The short-term oxygen demand (STOD) bioassay is a variation of BOD which requires time in the order of minutes or a few hours to conduct rather than 5 days or longer. The STOD requires a relatively sophisticated respiration cell with an oxygen electrode, continuous recorder, and ancillary equipment compared to that required for BOD determinations. However, endogenous growth rate, effect of substrate addition, and oxygen demand to the point of substrate exhaustion can be determined within 40 minutes for some types of compounds. When oxygen is fully utilized, the system may be aerated and further oxygen utilization followed. Vernimmen, et al (1967) reviewed previous research on this subject and described the equipment, procedure, and some results on such chemicals as sodium acetate, formaldehyde, methanol, isopropanol, isobutanol and phenol. In this study various types of acclimated and domestic sewage seed were used. Vernimmen and co-workers suggest establishing a suitable correlation factor between STOD and BOD for a given waste and predicting BOD by means of a STOD/BOD ratio in the same manner as COD is used in predicting BOD. Although appealing because of immediate results, the STOD bioassay has not received wide acceptance.

TABLE 4. TOXICITY OF VARIOUS COMPOUNDS AS DETERMINED BY BOD (Herman, 1959)

Substance Tested	Reported As	TC_{50}, mg/l*	Toxigram Type
Simple Inorganic Poisons			
Ammonium thiocyanate	NH_4SCN	5000	2
Boric acid	H_3BO_4	1000	2
Cadmium sulfate	Cd^{++}	142	1
Chromic sulfate	Cr^{+3}	117	1
Cobalt chloride	$CoCl_2$	64	1
Copper sulfate	$CuSO_4$	21	1
Mercuric chloride	$HgCl_2$	0.61	1
Potassium cyanide	KCN	15	1
Sulfuric acid	H_2SO_4	58	1
Inorganic Reducing Agents under Certain Conditions			
Ferrous sulfate	$FeSO_4$	–	3
Oxalic acid	$H_2C_2O_4$	43	1
Sodium metaarsenite	$NaAsO_2$	–	3
Sodium nitrite	$NaNO_2$	–	3
Sodium oxalate	$Na_2C_2O_4$	–	3
Inorganic Oxidizing Agents under Acid Conditions			
Potassium dichromate	Cr^{+6}	17	1
Sodium arsenate	Na_3AsO_4	100	2
Organic Acids and Derivatives			
Acetanilide	$C_6H_5NH{\cdot}COCH_3$	–	3
Formic acid	$H{\cdot}CO_2H$	550	4
Nitrobenzene	$C_6H_5NO_2$	630	4
Salicylic acid	$CO_2H{\cdot}C_6H_4{\cdot}OH$	110	4
Sodium benzoate	$C_6H_5{\cdot}CO_2Na{\cdot}H_2O$	–	3
Sodium o-benzoyl sulfimide (soluble saccharin)	$C_7H_4O_3NSNa{\cdot}H_2O$	1000	2
Tannic acid	$(HO)_3C_6H_2{\cdot}CO$	–	3
Alcohols, Aldehydes, Ketones, and Derivatives			
Acetaldehyde	$CH_3{\cdot}CHO$	230	5
Acetone	$CH_3{\cdot}CO{\cdot}CH_3$	–	3
Formaldehyde	$H{\cdot}CH{:}O$	740	4
Hexamethylenetetramine	$(CH_2)_6N_4$	–	3
Methanol	CH_3OH	–	3
Phenols and Cresols			
o-cresol	$CH_3{\cdot}C_6H_4{\cdot}OH$	940	4
m-dihydroxybenzene	$C_6H_4(OH)_2$	–	3
2,4-dinitrophenol	$(NO_2)_2C_6H_3OH$	100	1
Phenol	C_6H_5OH	1600	4
Chlorinated Hydrocarbons			
Chloroform	$HCCl_3$	–	3

*TC_{50} = Concentration at which oxygen utilization is reduced 50 percent.

Related Microbiological Methods

Montgomery (1967) and Ludzack and Ettinger (1963) thoroughly reviewed respirometric methods for the determination of biochemical oxygen demand, including the STOD procedure, Warburg respirometry, Barcroft differential manometry, Wilson six-unit recording respirometry, electrolytic respirometry, the Sierp apparatus, the Nordell odeometer, the oxyutilometer, and Sapromat A6 respirometry. Malaney, et al (1959) presented data on the toxic effects of metallic ions on sewage microorganisms using the Warburg procedure.

Biodegradability of organic chemicals in the aquatic environment is another important factor related to biochemical oxygen demand. This is of increasing concern because of the accumulation of chemicals, especially pesticides and detergents, in the beds of rivers, lakes, and estuaries. The behavior of organic chemicals in the aquatic environment was reported in a recent study by Buzzell, et al (1968). At sublethal concentrations, the BOD, COD, total organic carbon (TOC), and toxicity as determined by microbial and fish bioassay were all determined for a selected group of 20 compounds representing a variety of types of chemicals. Bacterial enumeration was used to indicate bacterial growth in biodegradation units. Theoretical oxygen demand (TOD) for each compound was compared with 5-day and 20-day BOD results. The comparison showed that seldom was TOD reached in the BOD determinations. Graphs showing all of the data obtained were plotted. Each compound had its own characteristic set of curves for BOD, COD, TOD, etc. A sound basis resulted from this study to further evaluate BOD and other measures of chemical effect on aquatic organisms. This approach might well be used in the study of chemical toxicity in the aquatic environment.

Earlier, Ludjack and Ettinger (1963) reviewed methods of estimating the biodegradability and treatability of organic water pollutants and how various types of data from BOD, respirometry, etc., procedures can be applied in practice to various contact treatment units.

Several excellent papers (Beak, 1957; Dobbins, 1964; Gannon, 1966; Nejedly, 1967; and Smith, et al, 1962) discuss laboratory BOD determination in relation to receiving stream BOD and the multiple factors that are involved in calculating or estimating downstream dissolved oxygen drop. In particular, papers by Dobbins (1964), Gannon (1966), Goodman and Dobbins (1966), and Smith, et al (1962) would be particularly useful in developing mathematical modeling or simulation of stream problems associated with dissolved oxygen depletion.

Other microbiological techniques for study of various types of water pollution are described in standard texts too numerous to mention here. Bacteria and other microorganisms are usually studied as indicators of fecal pollution. Papers by Kabler (1957, 1961), Khan (1964), Bonde (1966), Morrison and Fair (1966), O'Connell and Thomas (1965), Cooke and Bartsch (1959), Burman (1966), and Bick (1963) describe studies in which enumerations were made of *Escherichia coli*, coliforms, fecal streptococci, salmonellae, *Aeromonas, Pseudomonas, Clostridia,* microfungi, actinomycetes, and algae. Bick (1963) extended this list of organisms to include protozoa and other aquatic invertebrates in reviewing Central European ecological approaches in studying water pollution. According to this approach, organisms characteristically occur in various "saprobic zones" which are used to describe the degree of pollution. The procedures involved in the papers cited above are concerned primarily with sewage pollution or taste and odor problems. Burman (1966) reviewed the various procedures, media, equipment, etc., in bacteriological examination of water and describes a technique in which C^{14}-labelled compounds are incubated, the $C^{14}O_2$ evolved is absorbed on barium hydroxide, and counts of radioactivity are used to quantitate respiration. Since only 4 hours are required for completion, this technique might be a useful, more rapid variation of the standard BOD assay. A similar technique, using $C^{14}O_2$ in the study of photosynthetic activity of algae in the field, is used to determine trophic levels in various types of water (Butler, 1965).

SECTION VII

MARINE BIOASSAY

Any report or critique to be made of the methods used in bioassaying the effects of chemical pollutants on marine and estuarine forms can be presented concisely and to the point. That is, those bioassay techniques in which the flowing-seawater method is not used fall short of obtaining accurate tolerance limits, etc., for marine and estuarine species in regard to chemical pollutants. The flowing-seawater technique for both acute and chronic toxicity studies developed at the Bureau of Commercial Fisheries at Gulf Breeze, Florida, as described by Lowe (1964) comes closely to providing the necessary data regarding chemical toxicants to marine and estuarine forms.

In this technique, the chemical solution is contained in a stock solution bottle and is metered by means of a stopcock into a slanted mixing trough which contains running fresh seawater. The fresh seawater is kept in a holding tank at a constant level and is siphoned at a constant rate into the trough. From the trough, the toxicant-containing water flows by gravity over baffles into the chamber containing the test animals. A drain is situated at one end of the chamber to allow overflow and maintenance of a constant level of toxicant-containing water. The author states that this constant-flow system eliminated the need for aeration and that no attempt was made to control temperature and salinity. A record of the latter two values was kept however.

Data on marine studies are included in Appendixes A and B and may be identified by the names of the marine species listed in the second (Organism) column. Further identification is afforded by the Species Index (Appendix C).

Marine species most frequently used in bioassay include: :

Algae
    Dunaliella euchlora
    Platymonas sp

Crustacea
    Artemia salina – brine shrimp
    Callinectes sapidus – blue crab
    Carcinus spp – decapod crab
    Peneaus aztecus – brown shrimp
    P. duorarium – pink shrimp
    P. setiferus – white shrimp

Molluscs
    Balanus spp – barnacle
    Crassostrea virginica – oyster
    Mercenia mercenia – hard clam
    Mya spp – soft shell clam
    Ostrea spp – oyster

Fish
    Cyprinodon variegatus – sheepshead minnow
    Fundulus similis – longnose killifish
    Lagodon rhomboides – pinfish
    Leiostomus xanthurus – spot
    Mugil curema – white mullet
    M. cephalus – striped mullet
    Oncorynchus kisutch – coho salmon
    Petromyzon marinus – sea lamprey
    Salmo gairdneri – rainbow trout
    S. salar – Atlantic salmon
    S. trutta – brown trout

References to marine studies are made throughout the various sections of this report. It is of some interest to note that somewhat less than 10 percent of all papers reviewed were concerned with studies on the effect of chemicals on the marine organisms.

SECTION VIII

FIELD ASSESSMENT

Many ecological parameters must be taken into consideration when field studies are conducted. Even minor variations in most environmental factors such as temperature, rainfall, pH, dissolved oxygen, and sunlight can significantly affect the toxicity of many chemical compounds. Full discussion of these factors is presented in texts by Hutchinson (1957, 1967), Welch (1952), Ruttner (1953), and Odum (1959). One consideration of major importance is the food web. The introduction of toxic substances at any point in the web may interfere with the reproduction and well-being of higher animal forms.

Study of Residues in Aquatic Animals

The transfer of food energy from plants (the producers) through various animal organisms (the consumers) with repeated eating and being eaten is referred to as a food chain. The links in the chain seldom number more than five and usually many chains are interconnected with one another with the resulting pattern being called a food web. Figure 1 is a simplified diagram of a food web in western Lake Erie leading to the sheepshead. This diagram, modified from Daiber (1952) by Kendeigh (1961) shows the producers and consumers organized into nutritional or trophic levels. The lowest level (P) is composed of the producers that are able to use solar energy for the manufacture of food. At the second level (C_1) are the primary consumers or grazing herbivores; at the third level (C_2) the secondary consumers or small-size carnivores; and the fourth level (C_3) the larger carnivores. It is possible that additional consumers may be present (C_4). The consumer levels are not sharply defined because feeding behavior of some species may involve them in more than one level. Generally, the farther removed from the producers an organism is, the greater the likelihood it will feed on more than one level. Bacteria and fungi act as transformers (T) or decomposers and break down dead organic matter into nutrients that may be utilized by the producers (Ingols, 1959; Odum, 1959; Phillipson, 1966; and Welch, 1952).

Food webs are studied in a variety of ways including direct observation which is probably the least reliable. Stomach analysis of higher animal forms has been widely used for a great many years and has provided some useful information. When using this method, a major problem arises when plant juices and soft tissues must be considered because these are rapidly digested and practically impossible to identify. Precipitin tests have recently been used. An extract is made from a prey organism and this is injected into a rabbit which produces antibodies against this foreign protein. An extract is then made from a predator species and mixed with the rabbit antibodies. If this predator organism has been feeding on the prey organism, a white precipitate of antigen and antibody will be formed. In recent years, radioactive isotopes have also proven to be a most valuable tool in the study of the transfer of energy through trophic levels (Fujiya, 1965; Gakstatter and Weiss, 1967; and Miller, et al, 1966).

Meeks (1968) studied food chain organisms and how chemical contaminants can accumulate in the various trophic levels. A marsh adjacent to Lake Erie was treated with 3.9 millicuries of chlorine-36, ring-labeled DDT at a rate of 0.2 lb of technical DDT per acre. Radiolabeled DDT residues were traced until 15 months after the application. In his discussion of the work, Meeks stated that plankton and larger organisms rapidly removed the DDT from the water. Producer organisms contained their maximum residues between 1-3 days and most invertebrates contained their maximum residues several days later. These residues could have come directly from the

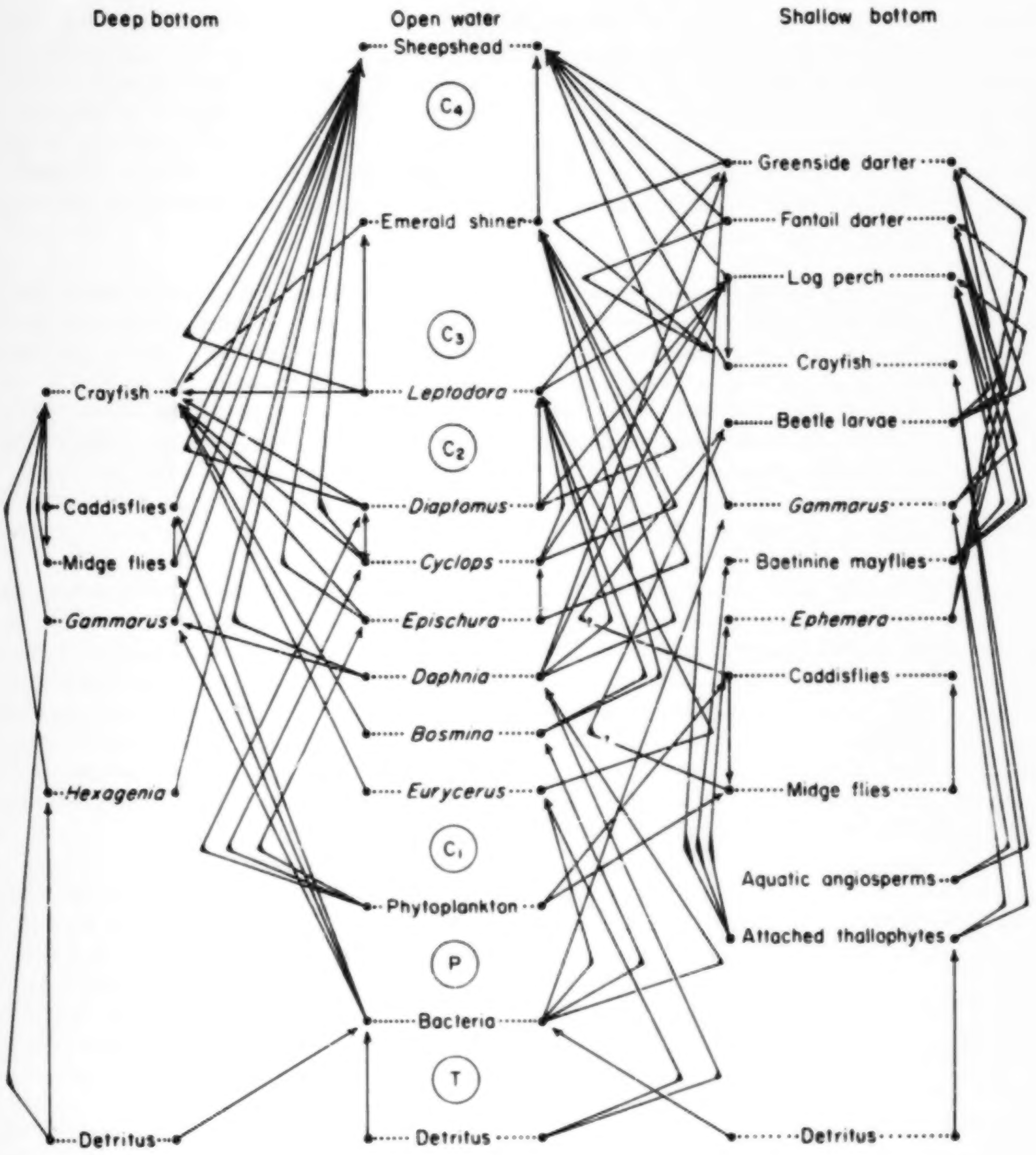

FIGURE 1. FOOD WEB IN WESTERN LAKE ERIE LEADING TO THE SHEEPSHEAD FISH

Species are separated into their different trophic levels (as modified from Daiber, 1952, by Kendeigh, 1961).

water or could have been picked up through the food web. There are several factors that indicate that the food web is the most important contributor. Herbivorous snails, at the second trophic level, contained their maximum levels at the same time as most primary producers. Odonata naiads and backswimmers, both carnivorous invertebrates occupying the third trophic level, reached their peak accumulation at 1 week. The red leech was probably the invertebrate closest to a secondary carnivore, fourth trophic level, and it had the latest and highest DDT levels of any invertebrate. Most vertebrates attained their maximum DDT residues after the invertebrates had their highest levels.

The DDT applied in this project would equal 0.07 ppm in water if all of the DDT had been available at the same time. Meeks used this figure as a base level for determining magnitudes of accumulation and recorded a sample of *Cladophora* collected at 3 days which exceeded this level by a factor of 3125. For a tadpole at 4 hours and a northern water snake at 13 months accumulation was over 500 times this base level. Concentrations ranging from 200 to 500 times occurred in some duckweed and bladderwort samples during the first week as it did in samples of carp and tadpole tissues. Most plant and invertebrate species exceeded the 0.07 ppm by a factor of 50 during the first week and throughout the project, vertebrate tissue often concentrated DDT more than 50 times the base level.

Miller, et al (1966) noted that molluscs characteristically accumulate pesticidal compounds at levels far above those present in the surrounding water. In laboratory experiments, Butler (1966) showed that oysters exposed to one ppb of DDT in flowing seawater may store 25 ppm in its tissues within 10 days. Terriere, et al (1966) reported concentration factors from water to plant of 500, water to aquatic animals other than fish of 1,000 to 2,000, and for rainbow trout, 10,000 to 20,000. Odum, et al (1969) found that suspended particulate organic matter may be a reservoir of DDT and some particles may contain residues thousands of times greater than the concentration occurring in the water. Fiddler crabs and other organisms that utilize plant detritus for food concentrate the pesticide in their tissues.

Nicholson (1967) stated that any DDT which is not excreted or metabolized can accumulate in tissues to some degree. It may then be passed on to the next higher trophic level by way of the food chain. Pesticides have been detected in aquatic animal tissues far removed from where the chemicals were actually used. Sladen, et al (1966) cited examples of Adelie penguins and a crabeater seal whose tissues contained DDT residues. These species reportedly do not leave the Antarctic ice pack. The pathway to these animals is probably the marine crustaceans upon which they feed.

Cade, et al (1968) reported finding high levels of pesticides in the eggs and tissues of fish-eating peregrine falcons of the Yukon area of Alaska, and Enderson and Berge (1968) reported similar findings in peregrines in northern Canada.

Hunt and Bischoff (1960) believed that DDD residues in fish caused the deaths of grebes in Clear Lake, California. Investigations showed the following DDD concentrations in samples taken 13 months after application of the DDD: in plankton, 10 mg/kg; in fat from plankton-eating fish, 902 mg/kg; in fat from carnivorous fish, 2690 mg/kg; and in fat from fish-eating birds, 2134 mg/kg (Nicholson, 1967). It is believed that grebes are unable to tolerate as high a level of DDD as some species of fish.

Fay and Youatt (1967) concluded that various pesticide residues found in tissues of aquatic birds in Lake Michigan did not appear to be an important factor in bird die-offs in this lake. Studies by Keith (1966), however, suggest that unusual mortality of aquatic birds in California was due to pesticide poisoning. Pesticides have also been linked with the declining population of fish-eating ospreys in Connecticut (Ames, 1966).

Within a given species there may be strains or populations in existence which are resistant to, or have a greater tolerance for, a particular chemical and, therefore, will survive under conditions that would normally prove fatal for this species. Populations of yellow bullhead, golden shiner, green sunfish, and bluegill have been found that were resistant to Endrin (Ferguson and Bingham, 1966), while some mosquito fish (Ferguson and Bingham, 1966; Ferguson, et al, 1966; and Toohey, et al, 1965), and black bullhead (Ferguson, 1967) have been found resistant to DDT. The resistance of fish to these chemicals appears to be genetic, i.e., passed on from one generation to the next. This resistance, however, may be lost unless the fish are kept in continual contact with the chemical. While these populations are now geographically limited, the possibility exists that eventually they could become widespread. Ferguson (1967) concluded that although selection of a resistant fishery may permit fish exposed to toxic chemicals to survive, it may ultimately produce a biological product dangerous to consumers of all sort, including man himself.

In recent years, numerous investigations have been carried out on the accumulation of chemicals in both vertebrates and invertebrates. Emphasis has been placed primarily on pesticides (see Appendix B).

Field Methodology

Field assessment studies may be divided into two general types although a clear-cut distinction is not always possible. The first type consists of field observations made on the effects of chemicals on aquatic life with little prior manipulation or study of the environment by the investigator. In many cases, the exact concentration of the chemical is unknown and may not be fully identified but may be simply referred to as a pesticide, an eradicant, an industrial pollutant, an organic pollutant, etc. These studies are usually made when a body of water becomes polluted from a pesticide-spraying operation, effluents from an industrial site, or from the application of chemicals directly into the body of water.

The effects of these chemicals are often expressed as a reduction in numbers of a particular species or the total absence of a species or population. Dead organisms are sometimes identified and counted, as in fish kills, or estimations made of percent mortality of a given population. Effects may sometimes be expressed by noting the presence of particular organisms, usually considered to be undesirable, such as *Sphaerotilus*, *Chironomus*, and tubificids. Sometimes pre-pollution studies have been made or comparisons made between similar bodies of water. This type of approach has been widely used in assessing the effect of thermal pollution on aquatic life.

The second type of field assessment consists of actual toxicity studies of the effects of known chemical concentrations on particular organisms. The studies are sometimes made in conjunction with laboratory toxicity tests and implies some prior manipulation of the environment. Results are usually expressed in lethal concentrations of the chemical studied. Field assessments of this type are conducted in various sizes and types of water bodies. The smallest are simple pools or channels, such as man-made troughs or tanks. Ponds, man-made or natural, are widely used for this type of assessment. Lakes and reservoirs are also used but allow the minimum control in a lentic environment due to size. Streams are used, but less than lentic bodies of water. The following discussion deals with the methods used in these toxicity studies.

Chemicals are applied to bodies of water for the purpose of assessing their effects on aquatic organisms in several different ways. A uniform distribution is of primary concern and, therefore, the size and depth of the body of water will be a major factor in determining which method to use. Cloth bags containing chemicals may be submerged at various depths and the chemicals allowed to diffuse out into the water or the bags may be towed from a boat. A common method is to pour or drip chemicals from the stern of a power boat into the wake caused by the motor. Power sprayers are used from boats in smaller bodies of water or from the shore. In the largest bodies of water, airplanes or helicopters are used.

Gjullin, et al (1949) studied the effects of DDT on trout, blackfly, and caddisfly larvae from Alaskan streams using 6-ft-long galvanized metal troughs set up adjacent to a stream. Water from the stream was pumped into the troughs and DDT was administered by a 1-gallon aspirator bottle calibrated with a stopcock to deliver the desired concentration per minute. Darsie and Corriden (1959) used bushel-sized galvanized tubs placed at various points along a stream filled with stream water at that point. Fish from the stream were placed in the tubs and the entire area was sprayed with Malathion by plane. Control tubs were covered during spraying and mortality of fish in all tubs was recorded after 4 hours. A similar method using aquaria was used by Schouwenberg and Jackson (1966). Snow (1963) treated pails of water from a stream with Simazine and then bass fry were placed in the pails and mortality recorded over a 96-hour period. Field studies were conducted on the toxicity of Lindane using 60 large fish tanks (1.5 m x 1.5 m x 30 cm) made from corrugated metal sheets. Each contained 50 fish and a different concentration of Lindane was used in each tank (Kok and Pathak, 1966). Gannon, et al (1966) used an experimental outdoor channel 640 feet long for water pollution studies. The channel consisted of 4-feet-long aluminum units that supported a waterproof plastic liner.

Attempts to approach more natural conditions in man-made devices have been made by other investigators. Applegate, et al (1961) and Howell, et al (1964) used running water raceways with an artificial stream bed constructed of materials from local streams, to test sea lamprey larvicides. These raceways were 6 feet wide and over 60 feet long. Productivity studies using artificial streams, supplied with water from an underground spring, were reported by Haydu (1968). The streams were 4 feet wide and ranged up to 700 feet long. Yeo (1967) used plastic pools (4 feet square by 2 feet deep) with a 2-inch layer of clay on the bottom. The pools held 180 gallons of water and aquatic plants, clams, and fish were added. A liter of natural pond water was added to introduce naturally-occurring microorganisms. These pools were used to study the influence of water hardness on dissipation and toxicity of Diquat. Parka and Worth (1965) also used plastic pools (6 feet in diameter and 15 inches deep) to study the effects of Trifluralin on fish. These pools were placed in form-fitting holes at the lowest point of a sloping field to form a catch basin. The pools were stocked with fish and the field was sprayed with a known quantity of Trifluralin. Over the next three days a sprinkler system soaked the field with ten inches of water which resulted in Trifluralin being carried into the basin in runoff water.

A more direct method, and one commonly used is to take qualitative and quantitative data on biota, apply the chemical to the body of water, and resample the populations. A control body of water may or may not be used. Numerous researchers have used this general approach with varied modifications (Eipper, 1959; Hoffman and Drooz, 1953; Hilsenhoff, 1966; and Surber, 1943).

Some investigators desire more control over the organisms being used in field assessments, and various methods are used to contain them. Live boxes or screened cages are commonly used. Patterson and Von Windeguth (1964) confined fish in live boxes and placed these in three shallow ponds that were sprayed with Baytex. Additional live boxes were placed in three control ponds and mortality was recorded after 24 hours. Mulla, et al (1963) and Wollitz (1963) did similar work in ponds using fish and frogs. The same technique has also been used in lakes (Jackson, 1960; Johnson, 1966; and Kallman, et al, 1962) and streams (Davis, 1954; Elson and Kerswill, 1967; Graham and Scott, 1958; Kerswill, 1967; Kerswill and Edwards, 1967; Schoenthal, 1963; and Schouwenberg and Jackson, 1966).

Another method used to restrict the movement of organisms is to enclose sections of the body of water. Harp and Campbell (1964) studied benthos in a farm pond by using plastic enclosures that divided the pond into sections measuring 12 by 18 feet. Different concentrations of Silvex were used in each section. Walker (1964) studied the effects of Dichlobenil on fish and aquatic plants in enclosures and open plots in selected farm ponds. Copeland and Woods (1969) also studied herbicidal effects on aquatic plants and used plots staked out in shallow areas of a lake. The plots were screened in with chicken wire to prevent plants from drifting away. Bonn and Holbert (1961) blocked off entire coves in a Texas lake with one-inch mesh nylon net to prevent movement of fish into and out of the cove. The coves were then treated with rotenone products.

A unique method to assess industrial pollution in a stream was used by Tatum (1966). A sampler, similar to the one designed by Hester and Dendy (1962) consisting of masonite plates, was placed in a fertilized pond for about one month to accumulate a dense growth of chironomid larvae (Diptera). These samplers were then placed in a river at stations above and below the outfall of an industrial site. Counts of larvae were made on each sampler after 1 week and comparisons were made between the average number of organisms on the samplers at stations above the outfall and on the samplers below the outfall. Williams and Mount (1965) measured the effect of zinc on periphytic communities by using a glass slide method. Periphyton populations were monitored by allowing periphyton to accumulate on glass slides submerged in running water canals for 2-week periods. One canal was used as a control and three other canals were treated with different concentrations of zinc.

The effects of chemicals sprayed into streams have been studied by monitoring the rate of downstream drifting of aquatic insects (Binns, 1967; Burdick, et al, 1960; Coutant, 1964; and Reed, 1966). Insects were continuously collected by Surber square-foot bottom samplers both before and after spraying and also in control streams. In another assessment, the effects of DDT sprayed in a stream were studied by determining the abundance of aquatic insects (Reed, 1966). An index was developed for those benthic insects found attached on rocks measuring approximately 15.2 centimeters in diameter. Butler (1965) studied the toxicity of pesticides by measuring primary productivity. By mixing known amounts of C^{14} with two suspensions of phytoplankton, one of which contains a known concentration of pesticide, it is possible to measure the interference of the pesticide with growth in a given period of time. Decreased carbon fixation provides an index of productivity, from which the relative toxicities of various pesticides may be compared. Other field methods used to detect the effects of chemicals on aquatic life include the use of other more specific radioactive tracers, the measurement of the effects of chemicals on the biochemical oxygen demand (BOD), and the fish brain cholinesterase inactivation technique. All of these methods have been discussed previously.

Sampling Equipment

Quantitative population samples taken to determine the effects of external factors are difficult to obtain. The effects of the external factors must be great enough to override the natural changing of the population brought about by migration, temperature, availability of dissolved oxygen, food supply, etc. Studies that require collecting organisms for evaluation also face the problem of valid sampling techniques because by definition a sample must be representative. Dimond (1967) stated that sampling procedures for stream insects are crude, and so much variation in the data results from their use that only major shifts in population size and structure can be detected. Lauer, et al (1966) said it was difficult to collect water samples that are truly representative of the concentration of the toxic agent to which the organism has been exposed.

Ricker (1968) in reference to collecting fish for productivity studies said that four truisms emerge: (1) most collecting methods are selective, with respect to species and size of individuals; (2) soundness of collecting procedures has too often been assumed and has too seldom been evaluated experimentally; (3) vast opportunities remain for discovering and developing new methods; (4) there is no substitute for operation experience on the part of the collector.

Several books provide valuable information on equipment and collecting procedures. Standard Methods for the Examination of Water and Wastewater (American Public Health Association, 1967), Limnological Methods (Welch, 1948), and Ecological Methods (Southwood, 1966) provide detailed information on the physical and chemical examination of water, information on equipment and methods for collecting biological material, and information on population sampling in freshwater habitats. Books by Ricker (1968) and Bennett (1962) give techniques for collecting and examining fish. The brief discussion that follows concerns only the most common methods used in the studies previously considered.

Though a wide variety of devices exist for sampling stream and lake bottoms, the three most widely used are the Ekman and Peterson dredges for lake bottoms, and the Surber square-foot sampler for shallow streams. Dredges take relatively shallow samples which are usually disturbed before they reach the surface and, therefore, the devices are not suitable for use in stratification studies. After the material is brought to the surface it is washed through a No. 30 mesh screen and the organisms sorted out. The screen collects only macroscopic bottom fauna. The Ekman dredge relies on its own weight to sink, has a rather weak spring to close the jaws and is, therefore, limited to use on bottoms which are soft and consist of finely divided mud. Large bivalves, sticks, or small rocks interfere with the closing of the jaws. The Peterson dredge is heavier, has additional attached weights, and can be used in sand and gravel. This dredge is sufficiently heavy, however, that it must be raised by a hoist. The Surber square-foot sampler is by far the most widely used stream sampler and is especially suitable for sampling on rocky bottoms which are shallow and possess current enough to hold the net in an open position. It has limited use in water deeper than three feet and again only macroscopic organisms are collected (Libby, 1964; Mackenthun, 1966; Mackenthun and Ingram, 1967; Southwood, 1966; and Welch, 1948).

Benthic and periphytic organisms are also collected by emplacement of a removable substrate. According to Southwood (1966), this is one of the most accurate collection methods. Collecting devices of this type are in various forms including building bricks (Elvins, 1962), asbestos-cement plates (Southwood, 1966), Plexiglas substrata (King and Ball, 1967), glass slides (Welch, 1948), and wire boxes containing rocks and sticks (Bull, 1968; Mason, et al, 1967; and Scott, 1958). N. W. Britt (1955) used concrete blocks on a rubble and gravel bottom to collect mayfly naiads. Unattended concrete block and Hester-Dendy multiple plate samplers are sometimes disturbed by anglers. This can be a problem when collecting devices must be left unattended in areas where large numbers of people use the water for recreational purposes. An additional problem encountered using this type of sampler especially in deep water, is that organisms not firmly attached may be lost when the sampler is raised.

The Kemmerer water sampler is probably the most widely used water collecting device and is also suitable for quantitative plankton samples. An advantage that the Kemmerer sampler has over the Juday plankton trap is that nannoplankton as well as net plankton is collected. A possible disadvantage of the Kemmerer is that motile zooplankters may tend to avoid it. The Juday plankton trap is a commonly used quantitative sampler which collects and removes the plankton in one operation. When the trap is brought to the surface, the water drains out and concentrates the plankters in a small net container. This collects only net plankton as the nannoplankton are so small they pass through the bolting cloth filter. The Juday trap is bulky, awkward to handle, and usually must be raised with a hoist. Qualitative plankton samples may also be collected with a bolting cloth tow net or with a plankton pump (Southwood, 1966; and Welch, 1948).

Ricker (1968) states that the use of electricity for capturing fish is one of the least selective of all active fishing methods. Too strong an electrical current, prolonged exposure, or contact with the electrodes, however, can kill fish, or cause damage that later proves fatal, and is of potential danger to the operators. Electrofishing can be done in both lakes and streams but water resistivity, variations in fish size, shape, or species, temperature, and fish mortality factors all have a bearing on the effectiveness of the shocker (Patten and Gillespie, 1966). Seining is the most common way to collect fish but is limited to shallow waters and bottoms that have few large boulders and few aquatic plants. Hoop and fyke nets are commonly used and according to Ricker (1968) can be both strongly selective and differently efficient in collecting fish species. For example, a net set parallel to the shoreline can be either more or less efficient than one perpendicular to it, depending on the species. Gill and trammel nets tend to be more efficient in capturing fishes adorned with external roughnesses, teeth, etc. Since these nets are stationary and depend on the fish moving to them, the fishing success may depend on abrupt changes in barometric pressure, wind-driven currents, water-level fluctuations, turbidity, and transmitted light. In very large bodies of water, purse seining and trawling are the most practical collection methods.

Table 5 shows the most commonly used items of collecting equipment, exclusive of dip nets and simple seines, with the general purpose for each item indicated. Of course, the quantitative samples may also be used to collect qualitative samples. The various traps and nets used for collecting fish result in acquiring qualitative information only. For fish population studies, some form of the capture-mark-recapture method must be used. There are many kinds of collecting devices in use though no single one is suitable for all types of habitats; a fact which complicates attempts to make comparative determinations (Anderson, 1962).

Indicator Organisms

Thieneman (Patrick, 1965) was the first to emphasize the fact that certain groups or associations of species were characteristic of a given type of environment. This does not mean however, that individual species are necessarily reliable indicators of environmental conditions in a particular area. Various researchers (Beak, 1965; Beck, 1957; Brinkhurst, 1966; Gaufin and Tarzwell, 1956; Lackey, 1957; Lackey, 1961; Mackay, 1969, Olson, 1957; Palmer, 1959; Palmer, 1963; Patrick, 1957; and Patrick, et al, 1967) have concluded that few individual species ~~as~~ indicators of pollution exist, but when a number of kinds of organisms are used in conjunction with chemical, physical, and bacteriological methods, the combination may be a reliable index. Table 6 is a list of organisms that have been associated with pollution of various types. When considering this table, it must be borne in mind that a number of ecological factors may influence the presence or absence of an organism and, therefore, changes in distribution and abundance of a species may not be related to pollution (Paine and Gaufin, 1956; Patrick, 1965; Lackey, 1957). Lackey (1957) pointed out that a cause and effect relationship does not necessarily exist simply because of abundance of an organism and occurrence of a defined pollutant.

Beak (1965) proposed a biotic index of water pollution based on presence and density of certain macrobenthic organisms. There were six stages in the index from normal fauna to total absence of fauna corresponding to increasing degrees of pollution. In most cases organisms were

TABLE 5. COLLECTING EQUIPMENT IN COMMON USAGE IN LIMNOLOGICAL STUDIES AND THE GENERAL PURPOSE FOR WHICH EACH IS USED

(Bennett, 1962; Ricker, 1968; Southwood, 1966; and Welch, 1948)

Equipment	General Purpose
	Benthos
Ooze sucker	Microfauna (qualitative) in uppermost layers
Ekman dredge	Macrofauna (qualitative) on soft bottoms
Peterson dredge	Macrofauna (quantitative) on hard bottoms
Triangle bottom dredge	Macrofauna (quantitative) on smooth bottoms
Wilding square-foot sampler	Macrofauna (quantitative) on soft or hard bottoms
Dendy inverting sampler	Macrofauna (quantitative) shallow moving streams
Surber square-foot sampler	Macrofauna (quantitative) shallow moving streams
Hess circular sampler	Macrofauna (quantitative) shallow moving streams
	Periphyton
Hollow square-foot-sampler	Macrofauna (qualitative) from hard objects having large areas
Wisconsin trap	Macrofauna (qualitative) from plants in shallow water
	Plankton
Kemmerer water sampler	Net and nannoplankton (quantitative)
Birge cone net	Net plankton (quantitative)
Wisconsin plankton net	Net plankton (quantitative)
Closing net	Net plankton (quantitative) from deep water verticle tows
Juday plankton trap	Net plankton (quantitative)
Clarke-Bumpus sampler	Net plankton primarily deep water
	Fish
Hoop and Fyke traps	Quiet shallow waters
Gill and tangle nets	Pelagic fish, various depths
Sunken trap nets	Lower depths in relatively shallow waters
Electric shocker	Shallow streams and lakes
Purse seine	Open water surface seining in large bodies of water
Trawl	Bottom, surface, or midwater depths in large bodies of water

TABLE 6. PARTIAL LISTING OF ORGANISMS COMMONLY ASSOCIATED WITH POLLUTION

Organism	Type of Pollution	References
Insects		
Chironomus riparius	Organic	Gaufin, 1957; Learner and Edwards, 1966; Paine and Gaufin, 1956
C. plumosus	”	Ingram, 1957
Culex pipiens	”	Gaufin, 1957; Ingram, 1957; Paine and Gaufin, 1956; and Gaufin, 1958
C. tentans	”	Gaufin and Tarzwell, 1952
Eristalis bastardi	”	Gaufin, 1957; Gaufin and Tarzwell, 1952; and Paine and Gaufin, 1956; Gaufin, 1958
E. tenax	”	Ingram, 1957
Glyptotendipes spp	”	Paine and Gaufin, 1956
Oligochaetes		
Limnodrilus spp	Organic	Brinkhurst, 1966; Gaufin, 1957; 1958; and Shrivastava, 1962
Tubifex spp	”	Brinkhurst, 1966; Gaufin, 1957, 1958; and Gaufin and Tarzwell, 1952
Fungi		
Fusarium aquaeductum	Organic	Cooke, 1957
Geotrichum candidum	”	”
Leptomities lacteus	”	”
Penicillium lilacinum	”	”
P. ochrochloron	Copper	”
Bacteria		
Aerobacter aerogenes	Fecal pollution	Kabler, 1957, 1961
A. cloacae	”	Kabler, 1961
Escherichia coli	”	Kabler, 1957, 1961
Sphaerotilus natans	Organic	Curtis, 1969; Herbert and Richards, 1963; and Patrick, 1968
Streptococcus durans	Fecal pollution	Kabler, 1961
S. faecalis	”	”
S. liquefaciens	”	”
S. zymogenes	”	”
Bryozoa		
Ctenostomata sp	Organic	Lackey, 1961
Protozoa		
Bodo caudatus	Organic	Lackey, 1957
Caenomorpha medusula	”	Lackey, 1961
Chaenea spp	”	”
Colpoda spp	”	Lackey, 1957
Colpidium spp	”	”
Dimastigamoeba gruberi	”	”
Diplophrys archeri	”	”

TABLE 6. (Continued)

Organism	Type of Pollution	References
Protozoa (Continued)		
Enchelyomorpha vermicularis	Organic	Lackey, 1957
Glaucoma pyriformis	"	Lackey, 1961
G. schintillans	"	Lackey, 1957
Hexamitus spp	"	Lackey, 1961
H. crassus	"	Lackey, 1957
H. inflatus	"	"
Loxodes vorax	"	Lackey, 1961
Mastigamoeba spp	"	"
Mastigella spp	"	"
Metopus spp	"	"
M. sigmoides	"	Lackey, 1957
Opercularia spp	"	"
Paramecium putrinum	"	Lackey, 1961
Pelomyxa palustris	"	Lackey, 1957
Polytoma uvella	"	Lackey, 1961
Poteriodendron petiolatum	"	Lackey, 1957
Saprodinium putrinum	"	"
Spirostomum spp	"	Lackey, 1961
Strombidium spp	"	"
Tetramilus spp	"	Lackey, 1957
T. pyriformis	"	Lackey, 1957, 1961
Tillina magna	"	Lackey, 1961
Trachelocerca coluber	"	"
Trepomonas spp	"	Lackey, 1957, 1961
Trigonomonas compressa	"	"
Trimyema compressa	"	"
Uahlkampfia guttalu	"	Lackey, 1957
U. limax	"	"
Urocentrum turbo	"	Lackey, 1957, 1961
Uroleptus spp	"	Lackey, 1961
Urophagus rostratus	"	Lackey, 1957
Urotricha spp	"	Lackey, 1961
Urozona butschlii	"	"
Algae		
Achanthes affinis	Hydrogen sulfide	Palmer, 1959
A. minutissima	Calcium carbonate	Patrick, 1965
Achnanthidium brevipes var *intermedia*	Salt brine (principally NaCl)	Palmer, 1959 "
Actinastrum hantzschii	"	"
Actinella spp	High acidity	Palmer, 1959, and Patrick, 1957
Agmenellum quadriduplicatum	Organic	Palmer, 1959
Amphora coffeiformis	Salt brine (principally NaCl)	"
A. ovalis	Paper mill wastes, salt brine, oil	"
Anabaena constricta	Organic	"
Anacystis spp	Salt brine (principally NaCl)	"
A. montana	Organic	"
Anomoeoneis serians var. *brachipira*	Iron	"
Arthrospira jinneri	Organic	"

TABLE 6. (Continued)

Organism	Type of Pollution	References
Algae (Continued)		
Astasia spp	Organic	Lackey, 1957
Asterionella formosa	Copper	Palmer, 1959
Caloneis amphisbaena	Paper mill wastes, hydrogen sulfide	"
Calothrix spp	Salt brine (principally NaCl)	"
C. braunii	Copper	"
Camphlodiscus spp	Hydrogen sulfide	"
Carteria multifilis	Organic	"
Ceratoneis arcus	Phenolic wastes	"
Chaetomorpha spp	Salt brine (principally NaCl)	"
Chlamydobotrys spp	Distillery wastes	"
Chlamydomonas spp	High acidity	"
C. ehrenbergii	Salt brine	"
C. reinhardi	Organic	"
Chlorella pyrenoidosa	"	"
C. vulgaris	"	"
C. variegata	Iron	"
Chlorobrachis spp	Organic	Lackey, 1957
C. gracillina	Distillery wastes	Palmer, 1959
Chlorococcum botryoides	Copper	"
C. humicola	Organic	"
Chlorogonium euchlorum	Distillery wastes, organic	"
Chromulina spp	Iron	"
C. ovalis	High acidity	"
Closterium acerosum	Chromium	"
Coccachloris elabens *(Aphanothece halophytica)*	Salt brine (principally NaCl)	"
Cocconeis diminuta	Paper mill wastes	"
C. pediculus	"	"
C. placentula	Phenolic wastes	"
Cryptoglena pigra	Organic	"
Cryptomonas erosa	High acidity	"
Cyclotella kiitzingiana	Phenolic wastes	"
C. meneghiniana	Hydrogen sulfide, salt brine	"
Cymatopleura solea	Phenolic wastes, paper mill wastes	"
Cymbella lacustris	Salt brine (principally NaCl)	"
C. naviculiformis	Copper, phenolic wastes	"
C. ventricosa	Salt brine, paper mill wastes, copper, hydrogen sulfide	"
Diatoma elongatum	Salt brine (principally NaCl)	"
D. vulgare	Phenolic wastes, paper mill	"
Diploneis elliptica	Wastes, oil	"
Dunaliella salina	Salt brine (principally NaCl)	"
Enteromorpha intestinalis	"	"
E. prolifeia	"	"
Entophysalis deusta *(Aphanocapsa littoralis)*	"	"
Euglena spp	"	"
E. acus	Chromium	"
E. adhaerens	High acidity	"
E. agilis	Organic	"

TABLE 6. (Continued)

Organism	Type of Pollution	References
Algae (Continued)		
E. deses	Organic	Palmer, 1959
E. gracilis	"	"
E. hiemalis	High acidity	"
E. mutabilis	"	Lackey, 1957; Palmer, 1959; and Sundaresan, et al, 1965
E. oxguris	Organic, chromium	Palmer, 1959
E. polymorpha	Organic	Lackey, 1959, and Palmer, 1959
E. sociabilis	Chromium	Palmer, 1959
E. stellata	Chromium, high acidity	Lackey, 1959, and Palmer, 1959
E. tatrica	High acidity	"
E. viridis	Chromium, high acidity, organic	"
Eunotia spp	Iron, high acidity	Palmer, 1959, and Patrick, 1957
E. exigua	High acidity	Lackey, 1957, and Palmer, 1959
E. lunaris	"	"
E. trinacria	"	"
Fragilaria virescens	Phenolic wastes	Palmer, 1959
Frustulia rhomboides var	Salt brine (principally NaCl)	"
saxonica	"	"
Gomphonema spp	"	"
G. acuminatum	Iron	"
G. herculaneum	Paper mill wastes, oil	"
G. olivacuum	Calcium	Patrick, 1965
G. parvulum	Phenolic wastes, organic	Palmer, 1959
Gyrosigma attenuatum	Salt brine (principally NaCl)	"
Hantzschia amphioxys	Hydrogen sulfide, organic	"
H. elongata	Salt brine (principally NaCl)	"
Lepocinclis ovum	High acidity, organic	Lackey, 1957, and Palmer, 1959
L. texta	Organic	Palmer, 1959
Lyngbya astuarii	Salt brine (principally NaCl)	"
L. digueti	Organic	"
Melosira arenaria	Salt brine (principally NaCl)	"
M. varians	Oil, organic	"
Meridion circulare	Salt brine (principally NaCl)	"
Microcoleus chthonoplastic	"	"
Navicula anglica	"	"
N. atomus	Chromium	"
N. cincta var *heufleri*	Salt brine (principally NaCl)	"
N. cryptocephala	Salt brine, organic, phenolic wastes, paper mill wastes	"
N. gregaria	Salt brine (principally NaCl)	"
N. linearis	Chromium	"
N. longirostris	Salt brine (principally NaCl)	"
N. minima	Hydrogen sulfide	"
N. minuscula	Salt brine (principally NaCl)	"
N. palea	Chromium, organic	"
N. pygmaea	Salt brine (principally NaCl)	Palmer, 1959, and Patrick, 1957
N. radiosa	Paper mill wastes, oil	Palmer, 1959
N. salinarum	Salt brine (principally NaCl)	"
N. subtilissima	High acidity, salt brine	Lackey, 1957, and Palmer, 1959
N. viridis	High acidity, copper	"

TABLE 6. (Continued)

Organism	Type of Pollution	Reference
Algae (Continued)		
Neidium bisulcatum	Copper	Palmer, 1959
Nitzschia acicularis	Organic	"
N. apiculata	Salt brine (principally NaCl)	"
N. epithemoides	"	"
N. frustulum	"	"
N. ignorata	Hydrogen sulfide	"
N. palea	Phenolic wastes, hydrogen sulfide, salt brine	"
N. trybliowella var *debilis*	Hydrogen sulfide	"
Ochromonas spp	High acidity	Lackey, 1957, and Palmer, 1959
Oscillatoria spp	Paper mill wastes, salt brine	Palmer, 1959
O. chalybea	Organic	"
O. chlorina	"	"
O. formosa	"	"
O. lauterbornii	"	"
O. limosa	"	"
O. princeps	"	"
O. putrida	"	"
O. tenuis	"	"
Pandorina spp	Paper mill wastes	"
P. morum	Organic	Lackey, 1957, and Palmer, 1959
Pediastrum spp	Paper mill wastes	Palmer, 1959
P. simples	Salt brine (principally NaCl)	"
Penium cucurbitinum	High acidity	"
Phacus parvulus	Organic	Lackey, 1957
P. pyrum	"	Lackey, 1957, and Palmer, 1959
Phormidium autumnale	"	Palmer, 1959
P. tenue	Salt brine (principally NaCl)	"
P. uncinatum	Organic	"
Pinnularia spp	High acidity, iron, salt brine	"
P. borealis	Phenolic wastes	"
P. subcapitata var *helseana*	Iron	"
Platymonas spp	Organic	Lackey, 1957
Polytoma citri	"	"
P. uvella	"	"
Pyrobotrys gracilis	"	Lackey, 1957, and Palmer, 1959
P. stellata	"	"
Scenedesmus spp	Paper mill wastes	Palmer, 1959
S. bijugatus	Salt brine (principally NaCl)	"
S. obliquus	Copper	"
S. quadricauda	Organic	"
Spirogyra communis	"	"
Spirulina subsalsa	Salt brine (principally NaCl)	"
Spondylomorum spp	Paper mill wastes	"
Stauroneis anceps	High acidity	Lackey, 1957, and Palmer, 1959
S. phoenicentern	Iron	Palmer, 1959
Stenopterobia intermedia	"	"
Stephanaptera gracilis	Salt brine (principally NaCl)	"
Stichococcus bacillaris	Organic	"

TABLE 6. (Continued)

Organism	Type of Pollution	References
Algae (Continued)		
Stigeoclonium tenue	Organic	Curtis, 1969, and Palmer, 1959
Surinella delicatissima	Iron	Palmer, 1959
S. linearis	”	”
S. ovata	Paper mill wastes, phenolic wastes, organic	”
S. ovata var *salina*	Paper mill wastes, phenolic wastes, hydrogen sulfide, organic	”
Symploca erecta	Copper	”
Synedra acus	Oil, salt brine	”
S. affinis	Salt brine (principally NaCl)	Palmer, 1959, and Patrick, 1957
S. pulchella	Paper mill wastes, salt brine	”
S. ulna	Paper mill wastes, phenolic wastes, oil	Palmer, 1959
Tabellaria flocculasa	High acidity	”
Tetraedron muticum	Organic	”
Tetraspora spp	Chromium	”
Trachelomonas spp	Salt brine (principally NaCl)	”
T. hispida	Iron	”
Trichodesmium spp	Salt brine (principally NaCl)	”
Ulothrix spp	Salt brine, paper mill wastes	”
U. zonata	High acidity	Lackey, 1957, and Palmer, 1959
Vanheurckia rhomboides var *crassenervia*	” ”	”
Xanthidium antilopaeum	”	Palmer, 1959

identified only to Family and were grouped according to feeding type and sensitivity to pollution.

In using groups of aquatic organisms as indicators of pollution, the absence or reduction in numbers of "clean-water" species may be as important, if not more so, than the presence of known pollutional forms (Anderson, 1962; Fremling, 1964; Gaufin, 1958, 1965; Gaufin and Tarzwell, 1952; and Leonard, 1965). Aquatic organisms usually considered to be "clean-water" organisms include mayflies, stoneflies, caddisflies, molluscs of the family Unionidae, and beetles of the family Elmidae. The absence of these organisms and the presence of physid snails, tubificids, *Eristalis tenax*, and *Chironomus pipiens* would indicate water highly degraded by organic wastes (Hinshaw, 1967; Ingram, 1957; Paine and Gaufin, 1956; and Young, 1961). Palmer (1959) lists over 40 species of algae that he considers "clean-water" forms. He also said that blue-green algae and flagellates are the algal groups most frequently encountered in the portion of a stream containing organic pollution. Palmer (1963) has compiled a listing of more than 600 species that are said to be tolerant of pollution.

The presence of large number of tubificids usually indicates a high concentration of organic matter. These worms can live in water low enough in oxygen that most other fauna will not survive (Brinkhurst, 1966, and Curry, 1965). King and Ball (1964) used wet weight ratios of tubificids to aquatic insects to indicate changes in water quality. Their results indicated that this technique may be useful in measuring organic pollution. Among the mayflies, there seems to be an order of sensitivity to organic waste and as pollution increases sensitivity declines in the following order: *Rhithrogena, Heptagenia, Ecdyonurus, Ephemerella*, and *Baetis*. An amphipod, *Gammarus pulex*, lives quite well even in badly polluted water as long as the oxygen content is not greatly lowered (Hynes, 1959). Ingram (1957) in discussing clams and snails, said that not enough is known about molluscan ecology to name any species a pollution indicator and though species such as *Psidium idanoensis, Physa integra, P. heterosteopha*, and *Musculium transversum* are found associated with organic waste, they are also found in areas unpolluted by domestic sewage or putrescible industrial waste.

Coliform bacteria are constantly present in alimentary discharges, are comparatively easy to enumerate, have long been considered indicative of fecal pollution (Gilderhus, 1966; and Kabler, 1957, 1961). Owing to special nutritional requirements a few species of fungi have been associated with certain types of pollution (Servizi, et al, 1966). Generally, however, there has been little correlation found between pollution and populations of aquatic fungi (Cooke and Bartsch, 1959).

Brinkhurst (1966) said that fish are not particularly easy to use as indicators because they are relatively difficult to sample, and their mobility makes it possible for them to avoid those parts of the environment which become intolerable for short periods of time. Katz and Gaufin (1953) studied the effects of organic pollution on fish distribution in a small Ohio stream. No species of fish were regarded as indicators of pollution although several were relatively tolerant of unfavorable conditions. They concluded that the number of species present and their relative abundance are the most important considerations when pollutional conditions are being evaluated.

Williams (1964) concluded that the search for biota or communities of biota which might be useful as indicators of water quality has been hampered by the lack of information on the environmental requirements of the various species and their resistance to specific chemical substances.

Concluding Remarks
(Field Assessment)

The value of field studies lies in the fact that more natural conditions are approached in the field than in the laboratory. This is important because the reaction of an organism to a chemical in the laboratory is not necessarily the same as it would be in nature. A price is paid for these natural conditions, however, because it is impossible to control or even to ascertain all of the variables in a field study. To complicate this further, in most field work there is a conspicuous lack of detailed water-quality data taken in support of the field observations. In this report, for example, approximately 220 papers dealing with field projects were carefully studied and evaluated. Of these, only about 50 contained definitive water quality information. It has long been recognized that the toxicity of a compound may depend on a number of interrelated factors, including temperature, pH, water hardness, dissolved oxygen content, and exposure time. For example, Cairns (1957) showed that considerable increases in toxicity may result during periods of low dissolved oxygen content, and that this may occur even when the oxygen supply is not low enough to be directly harmful to the organism. Burdick (1967) states that toxicants react with detritus, and organic or inorganic materials in the water or bottom sediments and that bacterial decomposition may alter chemicals to substances of greater or less toxicity. He concluded that even light penetration may have an effect. Only rarely are all or even a majority of these factors taken into consideration in conducting field studies of water pollution.

SECTION IX

FACTORS AFFECTING CHEMICAL TOXICITY IN WATER

Depending on the nature of a chemical, environmental factors influencing water quality may also affect the inherent toxicity of that compound to aquatic biota. Similarly, water quality itself can affect chemical toxicity. For these reasons, chemical-physical characterization of water is important whether it is used in a bioassay or studied in the field. Experimentation may have little significance without minimal characterization, that is, measurement of water temperature, pH, dissolved oxygen (DO), conductivity, oxidation-reduction potential, dissolved chlorides, and turbidity. Furthermore, when potentially toxic ions, e.g., heavy metals or halogens, are known or suspected to be present, analysis for these should be made. Without such data for an aquatic experiment, the toxicity of a chemical to an aquatic organism means only that for the conditions of that experiment is the chemical toxic at the concentration level reported, i.e., the toxicity data cannot be extended to any other type of water.

As pointed out previously in other sections of this report, this type of water characterization data was seldom given in the publications reviewed. Use of an unspecified, "standard water" throughout a bioassay study helps very little when an attempt is made to extrapolate from the study and predict how a chemical may behave in an entirely different water. If there is to be a serious attempt to employ multivariate analysis or mathematical modeling in predictive studies of chemical pollution problems, then the suggested type of water data must be taken, or completely standardized experimental conditions including chemically defined water must be employed. The following discussions concern the more important water-quality factors that may affect the toxicity of a chemical in aquatic environments.

Temperature

The biological significance of temperature in the aquatic environment has been recognized for many years. It was once said that a limnologist could obtain more information about a body of water with a thermometer than any other single instrument. Reid (1962) believes "from the broad and basically ecological point of view, the thermal properties of water and the attending relationships are doubtless the most important factors in maintaining the fitness of water as an environment." In several limnology texts (Reid, 1961, Ruttner, 1953, and Welch, 1952), accounts are given of thermal stratification, thermoclines, heat budgets, general thermal dynamics of water bodies, and the effects these factors have on aquatic life. Hutchinson (1957) gives an in-depth account of the thermal properties of lakes. In recent years as the use of streams and lakes by industry has increased, more investigators have been concerned with the effects of increased temperatures on aquatic organisms. There are several very recent, extensive bibliographies (over 1500 references) available on heated effluents and their effects on aquatic life (American Society of Civil Engineers, 1967; Kennedy and Mihursky, 1967; and Raney and Menzel, 1967). A reference manual on thermal effects on aquatic organisms was prepared by Wurtz and Renn (1965).

A great deal of attention has been placed on thermal effects on fish. Fish, like most aquatic organisms, are poikilotherms and therefore lack the means of maintaining an independent body temperature. Needless to say, water temperature is a critical factor in the life of a fish and in fish production. Each species has a thermal zone in which it can function in a normal manner with a higher and lower zone in which it can survive for certain lengths of time. The degree of success the fish will have in these less than optimal zones will depend on a multitude of factors including the health of the fish, stage of development, sex, diet, season of the year, and various water quality parameters (Alabaster, 1967; Alabaster and Welcomme, 1962; Brett, 1956; Hoar, 1956; Huet, 1965; Mihursky and Kennedy, 1967; Tarzwell, 1957; and Tyler, 1966).

A major factor affecting the ability of an organism to adapt to a new temperature is the previous temperature to which it has been exposed. Prosser and Brown (1961) define acclimation as the compensation by animals to persistent change in temperature, usually in the laboratory. Though not all authors make the distinction between acclimation and acclimatization, Prosser and Brown refer to acclimatization as compensations under field conditions which come about more slowly. Upper lethal temperatures tend to be closer to the acclimation temperature than lower lethal temperatures (Colton, 1959). Upper or lower lethal temperatures obviously have more meaning when the acclimation temperature is indicated. Table 7 lists the thermal death points of a number of species of freshwater and marine fish in relation to the acclimation temperatures. The table is a summary of work conducted by Brett (1956) and Jones (1964).

Laboratory studies conducted on thermal death points of various organisms may be of two basic types. These are acute or shock tests in which large temperature increases are usually completed in a few hours, and the chronic tests in which temperature increase is only a degree or two a day and the overall test lasts several months. Shock tests are of value in studying fish movements or when thermal loading is confined to a limited area. In these situations fish are likely to move rapidly from one temperature zone to another. Chronic tests are designed to approximate a condition of gradual exposure over considerable periods of time (Cairns, 1955, 1956).

Generally, fish of temperate regions are able to tolerate temperatures from 0 C to 30 C but resistance to the highest and lowest temperature varies with different species. Salmonids and other cold water fishes do not tolerate higher temperatures while warm water forms, such as the cyprinids, tolerate higher temperatures quite well. Marine species may be more sensitive to temperature change than freshwater species and immatures of both types are more sensitive than adults. In general, all abrupt changes in temperature can be harmful even if the changes are short lived.

Temperature may affect the fish directly or it may have an indirect effect. A change may be within the toleration limits of a fish but may alter the environment to the point where it is more suitable for another species (Tarzwell, 1957). This may come about in a number of ways including a reduction or an increase in food supply, interference with the spawning process, or alteration of the dissolved oxygen content of the water. Though other factors are also involved, fish only spawn when the water reaches a suitable temperature and this varies with different species. Water temperature may affect growth. For example, carp growth is very good between 20 C and 28 C, average between 13 C and 20 C, poor between 15 C and 13 C, and non-existent below 5 C (Alabaster, 1967; Colton, 1959; Fry, 1960; Huet, 1965; and Swift, 1965).

Though the physiological effects of heat on an organism are discussed in some detail by Brown (1957) and Prosser and Brown (1961), the actual cause of death by either heat or cold is not well understood. Various theories have been put forth concerning the mechanism of heat death including coagulation of protoplasm, inactivation of enzyme systems, lack of oxygen due to inactivation of the respiratory center, and the release of toxic materials from heat affected cells (Brett, 1956; Brown, 1961; Cairns, 1955; and Jones, 1964). Though the exact causes of death at high temperatures may not be clear, most investigators agree that multiple factors are involved.

TABLE 7. THERMAL DEATH POINTS OF FISH ACCLIMIZED AT THE INDICATED TEMPERATURES (FRESHWATER = F, MARINE – ATLANTIC = A, PACIFIC = P)

(Brett, 1956; and Jones, 1964)

Fish	Acclimation Temperature, C	Thermal Death-Point, C	Occurrence
Atlantic salmon	–	29.5-30.5	A-F
Atlantic salmon (grilse)	–	32.5-33.8	F
Atlantic salmon (parr)	–	29.8	F
Blacknose dace	10	28.8	F
Blacknose dace	20	29.3	F
Bluegill	15	30.7	F
Bluegill	20	31.5	F
Bluegill	30	33.8	F
Bluntnose minnow	25	33.3	F
Brook stickleback	25-26	30.6	F
Brook trout	5	23.7	A-F
Brook trout	10	24.4	A-F
Brook trout	15	25	A-F
Brook trout	20	25.3	A-F
Brook trout	25	25.3	A-F
Brown bullhead	15	31.8	F
Brown bullhead	20	33.4	F
Brown bullhead	30	36.5	F
Brown trout	26	26	A-F
Brown trout (fry)	5-6	22.5	F
Brown trout (fry)	20	23	F
Brown trout (yearling)	–	25.9	A-F
Brown trout (parr)	–	29	A-F
Carp	20	31-34	F
Chinook salmon (fry)	15	25	F
Chinook salmon (fry)	20	25.1	F
Chum salmon (fry)	15	23.1	F
Chum salmon (fry)	20	23.7	F
Coho salmon (fry)	15	24.3	F
Coho salmon (fry)	20	25	F
Common shiner	15	30.3	F
Common shiner	30	31.0	F
Creek chub	10	27.3	F
Creek chub	15	29.3	F
Creek chub	25	30.3	F
Emerald shiner	10	26.7	F
Emerald shiner	15	28.9	F
Emerald shiner	25	30.7	F
Fathead minnow	10	28.2	F
Fathead minnow	20	31.7	F
Fathead minnow	30	33.2	F
Gizzard shad	25	34.3	A-F
Gizzard shad	30	35.9	A-F

TABLE 7. (Continued)

Fish	Acclimation Temperature, C	Thermal Death-Point, C	Occurrence
Golden shiner	15	30.5	F
Golden shiner	25	33.2	F
Golden shiner	30	34.7	F
Goldfish	10	30.8	F
Goldfish	20	34.8	F
Goldfish	30	38.6	F
Guppy	30	34	F
Largemouth bass	20	32.5	F
Largemouth bass	25	34.5	F
Largemouth bass	30	36.4	F
Mosquito fish	15	35.4	A-F
Mosquito fish	20	37.3	A-F
Mosquito fish	30	37.3	A-F
Opaleye	20	31.4	P
Opaleye	30	31.4	P
Perch	–	23-25	F
Perch	10	25.0	F
Perch	15	27.7	F
Perch	25	29.7	F
Pink salmon (fry)	5	21.3	F
Pink salmon (fry)	10	22.5	F
Pink salmon (fry)	20	23.9	F
Pumpkinseed	25-26	34.5	F
Rainbow trout	–	28	A-F-P
Rainbow trout (Kamloops var)	11	24	P-F
Roach	20	29.5	F
Roach	25	30.5	F
Roach	30	31.5	F
Sockeye salmon (fry)	5	22.9	F
Sockeye salmon (fry)	10	23.4	F
Sockeye salmon (fry)	20	24.8	F
Tench	–	29-30	F
White sucker	25	29.3	F
Yellow Perch	15	27.7	F

When the temperature goes beyond the thermal zone optimal for the organism, evidence indicates the general resistance to other adverse conditions is reduced. Hynes (1959) stated that several workers have shown that a rise of 10 C may halve the survival time of test animals. It has been reported that an increase in temperature caused an increase in toxicity in fluorides (Angelovic, et al, 1961), cyanide (Cairns and Scheier, 1963), sodium pentachlorophenate (Crandall and Goodnight, 1959), phenol (Brown, et al, 1967), various pesticides (Mahdi, 1966, and Macek, et al, 1969), as well as a possible reduction in resistance to disease (Cairns, 1955, and Turnbull, et al, 1954). It has also been reported that anesthesia with alcohol was induced more rapidly in fish when the temperature was increased. Though it may not appreciably affect the toxic threshold, an increase in temperature may affect the length of time required for a given concentration to kill an organism. Hester (1959) found that if 40 F tests were continued beyond 3 days, the kill of fish by the end of the twenty-first day was approximately the same as 70 F tests conducted for 3 days. When all tests were run at 3 days, however, more rotenone was required to kill fish at 40 F than at 70 F. Similar findings were reported by Lloyd (1965) and Cairns and Scheier (1957). The rate of uptake of chemicals by aquatic organisms increases with an increase in temperature (Das and Needham, 1961). This occurs probably because of the increase in metabolic rate which accompanies the increase in temperature.

An interesting example of the effects of temperature on fish behavior was reported by Loeb, et al (1966). Brown bullheads *(Ictalurus nebulosus)* were killed when exposed to 50 ppb of 4-iodo-3-salicylanilide at temperatures of 5 C or 21 C. When bottom sediments were added, the bullheads would bury themselves in the sediment at 5 C and thus escape the toxic chemical. At 21 C, however, the fish would not bury themselves and were killed by the chemical.

Results of field studies conducted to determine the effects of increased temperatures on aquatic life are usually recorded as a reduction in numbers of individual organisms, reduction in species (with or without reduction in numbers of individuals), or the presence of indicator organisms (Geen and Andres, 1961; Mann, 1965; Trembley, 1960; and Wurtz and Dolan, 1961). Various types of organisms are useful in these studies. Trembley (1965) conducted a five year study of heated discharges in a Pennsylvania river and outlined the types of useful organisms and made some brief remarks about each group. The numbers of species of periphyton tended to be reduced in high temperatures but individual species were often present in great numbers. Most aquatic invertebrates tended to increase during winter months and undergo reduction in the summer. Insect larvae of the family Tendipedidae were the most tolerant invertebrates in the heated water areas. A rooted aquatic plant, *Potomogeton,* was found growing well in temperatures ranging from 35 C to 37 C. Certain species of blue-green algae, primarily *Oscillatoria,* were found to be the most heat-tolerant and were observed growing well in temperatures up to 45 C. During the summer, fish left the heated-water zone and were apparently attracted to the heated water areas during the winter months. Plankters drifted with the current and because of this were not considered suitable organisms to work with in lotic environments.

The Aquatic Life Advisory Committee (1956) in discussing water quality requirements for freshwater fish concluded that "any change in the temperature of the aquatic habitat will affect the animals and plants living in it, even though the change remains within their ranges of thermal tolerance. Because there is a relationship between temperature and the solubility, dissociation and stability of the substances dissolved or suspended in water, a change in temperature will have an indirect effect upon aquatic organisms, entirely apart from any direct effect, through alteration of the physical and chemical characteristics of their environment. Since body temperature of a fish or lower aquatic organism is very close to that of the water, a change in temperature will have direct effect by action upon the metabolic rate, growth, reproduction and other vital processes. It should be pointed out further that, as a consequence of the temperature effect upon one species, a change in temperature might alter the biotic environment of another species, thereby affecting the latter indirectly through an increase or decrease in food or shelter. The complexity of the problem is increased by the fact that the nature and magnitude of the effects upon aquatic organisms are related, not only to the temperature itself, but also to the rate at which it is changed and to the duration of the altered level".

pH

The most frequently used index of hydrogen ion activity is pH. The pH of natural waters may range from extremes of 1.7, found in an African lake, to 12.0 recorded from some Japanese lakes. Normally however, surface water pH is between 6.0 and 9.0. Factors influencing pH in unpolluted bodies of water are currents, which serve to keep the waters mixed; biological processes such as photosynthesis and respiration; and the composition of the rocks and sediments of the substrate (Jordan and Lloyd, 1964; National Technical Advisory Committee, 1968; and Reid, 1961). Hutchinson (1957) states that in practically every case where the water is neither very acid nor very alkaline, it may be assumed that the pH is regulated by the carbon dioxide-bicarbonate-carbonate system.

Determination of pH is not a measure of total acidity or alkalinity in water. Many compounds may be in water in unionized portions of weakly ionizing acids such as phosphoric, carbonic, fatty acids, protein compounds, or as hydrolyzing salts such as ferrous or aluminum sulfate. The latter are referred to as acid buffers. When acidity is measured by titration using a dye like methyl orange with an end-point at pH 4.5, the value is termed "free acidity". If the titration is carried by alkali addition to the end point of phenolphthalein at a pH of 8.3, the value is called "total acidity" and will include the weak acids, acid salts, and with sufficient time for reaction between alkali additions, some acidity due to slowly hydrolyzable compounds.

Alkalinity is usually imparted by the bicarbonate, carbonate, and hydroxide components of a natural or treated water supply. These ions are the so-called alkali buffers. In determining alkalinity, if the solution is titrated to the phenolphthalein end point of 8.3, the alkali fraction measured is that contributed by the hydroxide and half of the carbonate. Indicators responding in the pH range of 4-5 are used to measure the "total alkalinity" contributed by the hydroxide, carbonate, and bicarbonate.

Alkaline buffering capacity of water in some limestone areas, for example, may partially neutralize acidic components of an effluent. Where carbon dioxide content is high, alkali components of a waste effluent may be partially neutralized. Total acidity and alkalinity are features of water quality that are often overlooked in considering effluent release, and also in conducting bioassay or field studies of chemical toxicity.

When pH is the only factor considered, the toleration limit of most organisms falls in the range of 5.0 to 9.0 (Jones, 1964; Doudoroff and Katz, 1950; and Hynes, 1966). Fry (1960) concluded that the general range for good fish production was 6.7 to 8.6. McKee and Wolf (1963) state that of waters which support a good fish fauna, only 5 percent have a pH of less than 6.7 and only 5 percent have a pH over 8.3. The permissible range for fish depends on several factors including temperature, age, dissolved oxygen, prior acclimatization, and the content of various anions and cations.

The exact cause of death of fish in low or high pH waters is unclear though Tarzwell (1957) has stated that an unsuitable pH may interfere with oxygen uptake. It has been reported (Jones, 1964, and Aquatic Life Com., 1955) that fish are killed in acid waters by precipitation and coagulation of the mucous on the gills and by coagulation of the gill membranes themselves.

The pH of water may have considerable influence on the toxicity of certain chemicals. The pH value will determine the degree of dissociation of weak acids and bases, some of which may be more toxic in molecular than ionic form (McKee and Wolf, 1963; Hynes, 1966; and Cairns and Scheier, 1963). Highly dissociated inorganic acids do not appear to be toxic at pH values above 5.0 and highly dissociated inorganic alkalies do not appear to be toxic below 9.0 (Aquatic Life Com., 1955).

The effect of pH on the toxicity of specific compounds has been reported. An increase in toxicity brought about by a decrease in pH was reported for pentachlorophenol and sodium pentachlorophenate (Goodnight, 1942, and Crandall and Goodnight, 1959), nickel cyanide (McKee and Wolfe, 1963), and sodium sulfide (McKee and Wolfe, 1963, and Tarzwell, 1957). Within certain ranges, pH may have little or no effect on toxicity. Henderson, et al (1958, 1959) reported no differences in toxicity for several chlorinated hydrocarbon insecticides when the pH was varied from 7.4 to 8.2. Loeb, et al (1965) conducted studies on ergot derivatives on surfacing behavior of fish, and found no change in response when pH was changed from 6.3 to 7.2. Marking and Hogan (1967) found little difference in toxicity of Bayer 73 to fish in a pH range between 6.4 to 8.0. At a higher pH (10.0) and a lower pH (5.0), the toxicity of this compound was reduced. Mount (1966) in a flow-through study showed that zinc was always more toxic at a high pH than at a low pH, and further that water hardness was also an important factor.

Dissolved Oxygen

The amount of dissolved oxygen (DO) present is one of the most significant chemical parameters in the study of surface waters. The amount of oxygen that can be dissolved in water at any one time is dependent upon (1) water temperature, (2) partial pressure of the oxygen in the atmosphere in contact with the water, and (3) salinity.

Photosynthesis in algae and higher aquatic plants is one source of DO in natural waters. The rate of photosynthesis depends on many factors but the major one is light. The depth that light penetrates the water (euphotic zone) is determined by turbidity, color, and the absorptive effect of the water itself. Another important source of oxygen is the atmosphere. Factors which will influence the rate at which oxygen will dissolve into the water from the atmosphere include (1) wave action, or other surface disturbances, (2) the difference in partial pressure between the atmosphere and the water, and (3) the moisture content of the atmosphere.

There may be considerable diurnal and seasonal fluctuations in DO in a stream or lake primarily due to changes in water temperature and photosynthetic rates. Water temperatures vary from one season to another and deep lake water may vary considerably from the surface to the bottom, e.g., during thermocline formation. Though photosynthesis does not occur at night, aquatic plant respiration continues and oxygen is utilized. The amount of oxygen that is used in aerobic biochemical action in the decomposition of organic matter (BOD) also causes extreme fluctuations in DO available for aquatic organisms.

Oxygen requirements of fish and other aquatic organisms vary with the species and are affected by age, degree of activity, size, prior acclimatization, and health of the organism. Environmental factors influencing DO requirements or interfering with oxygen uptake are temperature, pH, carbon dioxide, and dissolved solids. Temperature appears to be the major factor because as the temperature increases, the metabolic rate of cold-blooded animals increases along with oxygen uptake. At the same time, the solubility of oxygen in water decreases as temperature increases. This is discussed in excellent detail with a tabulation of the water solubility of oxygen in Standard Methods (American Public Health Association, 1967).

Jones (1964) summarized the work of various investigators (Table 8) who conducted laboratory studies on DO requirements of fish at various temperatures. Jones pointed out that these figures were somewhat low compared with observations made in the field at similar temperatures. It follows, however, that while fish may survive short periods of stress under laboratory conditions, this does not mean they will be able to survive indefinitely, feed, reproduce, grow, and compete with other organisms.

Doudoroff and Warren (1962) found that sublethal adverse effects of low DO on fish included reduction in swimming speed and loss of weight. The gross efficiency of food conversion was not greatly reduced in fish maintained on an unrestricted diet until the DO level dropped below 4 ppm. The reduction in growth rate was attributed to loss of appetite. It was also found that sac fry hatched from eggs in waters with a low DO content were small and weak.

A low level of DO may in itself be a lethal factor for various aquatic organisms and may also cause an increased toxicity in a variety of chemicals. Several investigators have reported an increase in the toxicity of chemicals due to decreased DO including various petroleum products (Tagatz, 1961), unionized ammonia (Downing and Merkens, 1955), potassium dichromate (Cairns, 1965), potassium cyanide (Downing, 1954; and Cairns, 1965) zinc, lead and copper salts (Reiff, 1964), and various other inorganic salts (McKee and Wolf, 1963).

Suspended Solids and Turbidity

Turbidity may be defined as the degree of opaqueness produced in water by suspended particulate matter. In much of the literature, turbidity and suspended solids (or suspensoids) are used as synonyms. The particle size, shape, and refractive index have more influence on turbidity than weight composition (American Public Health Association, 1967). The interplay of light on the suspended material along with the reflection from the sky or bottom are also responsible for the apparent color of the water. This is distinguished from true color which is derived from substances in solution or in the colloidal state.

Turbidity is measured in Jackson turbidity units (JTU) which is the distance through a column of water at which the image of a standard flame from a candle is no longer visible. The standard unit is that condition produced by 1 ppm Fullers earth in distilled water. Turbidity has a profound effect on natural light penetration which can be determined by the use of a photronic cell or a Secchi disk. The measure of natural light penetration, however, is not a good measure of turbidity because other factors affect light penetration including intensity, cloud cover, water disturbance, and direction of the sunlight.

Suspended solids that occur naturally in water bodies include plankton, organic and inorganic detritus, and silt. These suspended solids are augmented by a multitude of materials in discharges from population centers, agricultural, and industrial sites. McKee and Wolfe (1963) note that differentiation between suspended and settleable solids are often not clear because the terms are sometimes confused in the literature. Until settled to the bottom, all settleable solids are suspended solids and the rate of settling is dependent on quiescence, temperature, density, flocculation, and other factors.

TABLE 8. MINIMUM OXYGEN VALUES AT VARIOUS TEMPERATURES AT WHICH FISH CAN EXIST UNDER LABORATORY CONDITIONS

(Jones, 1964)

Fish	Oxygen, ppm	Temperature, C
Bleak	0.68-1.44	16
Blunt-nosed minnow	2.25	20-26
Brook trout	2.0	10
Brook trout	2.2	15
Brook trout	2.5	20
Brook trout	1.52	3.5
Brook trout	2.4	23
Brook trout	2.5	19-20
Brook trout	1.35-2.35	15.6
Brown bullhead	0.3	30
Brown trout	1.13	6.4
Brown trout	1.16	9.5-10
Brown trout	2.13	18
Brown trout	2.8	24
Brown trout	1.28-1.6	9.4
Brown trout	1.64-2.48	17.2
Brown trout	2.9	–
Carp	1.1	30
Carp (mirror)	0.59-2.5	16
Coho salmon	1.3	16
Coho salmon	1.4	20
Coho salmon	2.0	24
Dace	0.57-1.1	16
Eel	1.0	17
Goldfish	0.5	10
Goldfish	0.6	20
Goldfish	0.7	30
Perch	1.1-1.3	16
Rainbow trout	2.4-3.7	16
Rainbow trout	2.5	19-20
Rainbow trout	0.83-1.42	11.1
Rainbow trout	1.05-2.06	18.5
Roach	0.67-0.69	16
Salmon parr	2.0-2.2	8
Smallmouth bass	0.63-0.98	15-16
Steel-colored shiner	2.25	20-26
3-spined stickleback	0.25-0.50	–
Tench	0.35-0.52	16
Yellow perch	2.25	20-26
Yellow perch	0.37-0.88	15.5

Cairns (1967) described the adverse effects of suspended solids on aquatic biota and acknowledged that the effects would vary with the species and stage of development. A brief summary of this discussion follows:

(1) Reduction of light penetration – This may restrict the growth of photosynthetic forms and, as they are the base of the food web, this could have widespread effects on all other organisms.

(2) Mechanical or abrasive action – This is of particular importance to gill-breathing organisms, such as fish and mussels, because gill impairment not only effects respiration and excretion but may have other widespread metabolic effects.

(3) Blanketing action or sedimentation – This has a deleterious effect on fish spawning sites and in fact may make large areas useless for spawning. Benthic organisms which are a valuable food source for fish may be eradicated.

(4) Availability as a surface for growth of fungi and bacteria – The presence of particulate matter may enable the environment to support substantially increased populations of microorganisms.

(5) Adsorption and/or absorption of various chemicals – This may lead to a buildup of toxic substances in a limited area with a possibility of sudden release.

(6) Reduction of temperature fluctuations – Probably of little importance since particulate concentration would have to be extremely high.

Reduced light penetration will greatly influence productivity. Little plant or benthic productivity can be expected when the turbidity exceeds 200 JTU (National Technical Advisory Committee, 1968). Buck (Tarzwell, 1957) reported the average volume of net plankton in clear ponds was eight times greater than from turbid ponds. Buck also stated (Fry, 1960) that virtually no light is transmitted beyond three inches when suspended solids reach 150 ppm. Most predacious fish feed by sight and in turbid waters have difficulty competing with such bottom-feeder fish as carp, buffalo, and carpsuckers.

Heavier particles of suspended material will settle out and may in this way reduce benthic production. Generally, benthic productivity increases with a change from fine to coarse substrates. Only small amounts of sand and silt shifting in and around the gravel will eliminate much of an area suitable for aquatic insects and other benthic organisms (Aquatic Life Advisory Committee, 1956). Spawning sites for fish are greatly altered by silting, and fish eggs may not receive enough oxygen when covered with fine sediments. A covering of silt may also prevent metabolites from being washed away (Trama and Benoit, 1960).

Reviewing data from other investigations, Tarzwell (1957) stated that in order for suspended solids to be directly harmful to fish the material must be present in very large amounts. Herbert and Merkens (1961) exposed trout to suspensions of kaolin and diatomaceous earth at concentrations of 270 ppm, and substantial numbers of the fish died. Concentrations of 90-100 ppm were less harmful and concentrations of 30 ppm had no observable effect. Wallen (Aquatic Life Advisory Committee, 1956) reported that fish lived for at least short periods (approximately a week) in silt concentrations of 100,000 ppm. The fish died in a few hours when exposed to concentrations of 175,000 to 225,000 ppm.

MacLeod and Smith (1966) found that the rate of metabolism and swimming endurance were reduced in minnows exposed to sublethal concentrations (100-800 ppm) of suspended wood fibers. Herbert and Richards (1963) reported reduced growth in trout kept in pulp suspensions of 50 and 100 ppm for 40 weeks, but concluded that streams containing concentrations of these suspended solids as high as 200 ppm and sometimes higher may support a "reasonable" fish population. They also stated that a fishery is likely to be seriously harmed if the average concentration is greater than 600 ppm.

Herbert, et al (1961) reported a reduction in numbers of trout in a stream polluted with suspended solids (1000 ppm) which was the only polluting material in the stream. He attributed trout reduction to effects on spawning sites, reduction in available food organisms, and some harmful effects directly to the fish.

Smith, et al (1963, 1965, 1966) and Kramer and Smith (1966) have conducted a series of studies on the effects of suspended material from industrial sites. They stated that fish in streams receiving woodfiber wastes may suffer deleterious effects from exposure to sublethal concentrations of suspended fibers. They further concluded that the effects of suspended fibers on fish mortality would depend on the species of fish, type of wood fiber, processing method, DO, concentration, and to a lesser degree, temperature.

When high concentrations of suspended solids are present, death of fish may be due to clogging of the gills (Brown, 1957; Thompson, 1963; and McKee and Wolfe, 1935). Large populations of planktonic organisms such as diatoms and protozoans may produce irritation of fish gills, a condition referred to as sestonosis (Fry, 1960).

There is little information on the effect of turbidity on the toxicity of chemicals. Though the effects of the turbidity are not known, many investigators acknowledge its importance and it is often measured in both laboratory and field studies (see Appendices A and B). Wallen, et al (1957) conducted toxicity studies on a variety of chemicals and carefully measured the turbidity both before and after the tests. They concluded their paper by stating that it would be important to determine if variations in turbidity would significantly affect the toxicity of chemicals, especially those that react to reduce turbidity. Schoenthal (1963) found that mortality in trout exposed to DDT was reduced when turbidity and alkalinity were increased. This may have been due to adsorption of the DDT by the sediment. Brungs and Bailey (1966) have shown that Endrin toxicity to fish is not greatly reduced unless a highly absorptive material such as activated carbon is present.

Other Factors

Among other water quality factors affecting chemical toxicity in the aquatic environment, water hardness and CO_2 content are probably the most important.

Hardness of water is chiefly attributed to calcium and magnesium ions. Water containing more than 40 ppm total hardness is generally considered hard water while less than this amount indicates soft water. Hardness in natural water can also be correlated with dissolved solids, and sometimes with alkalinity. Increased toxicity of the following chemicals has been reported for hard water: antimony potassium tartrate (Tarzwell and Henderson, 1960), Dipterex (Henderson and Pickering, 1968), and Fermate (Pickering and Henderson, 1966). Soft water increased the toxicity of the following chemicals: Sarin (Pickering and Henderson, 1959), copper and zinc (Sprague and Ramsay, 1965), fifteen metal compounds (Tarzwell and Henderson, 1960), hexavalent chromium (Trama and Benoit, 1960), methyl methacrylate, styrene and vinyl acetate (Pickering and Henderson, 1966), zinc (Mount, 1966, and Cairns and Scheier, 1958), Cumate (Pickering and Henderson, 1966), and copper sulfate (McKee and Wolfe, 1963). Water hardness had little or no effect on the toxicity of the following chemicals: antimony trioxide (Tarzwell and Henderson, 1960), ten organic phosphorus compounds (Henderson and Pickering, 1958, 1959), twelve petrochemicals (Pickering and Henderson, 1966), eight organic cyanides (Henderson, et al, 1961), cyanide (Cairns and Scheier, 1963), and ten phosphorus and chlorinated hydrocarbon pesticides (Pickering and Henderson, 1966).

Dissolved carbon dioxide is important in the aquatic environment, especially to plants. Although a product of respiration, the amount of CO_2 in the body of many animals determines respiration rate. Its primary role in photosynthesis has long been known along with its importance in the carbon-dioxide-bicarbonate system that determines the pH of many natural bodies of water. Carbon dioxide can also affect the toxicity of chemicals in water. At concentrations below 30 ppm, carbon dioxide is generally not toxic to fish. Above this level, it may be limiting in various ways, or lethal at high concentrations depending on the fish species involved. The effect of carbon dioxide on aquatic organisms is closely associated with DO and is mediated largely by ambient water temperature. The significance of carbon dioxide in aquatic environs is discussed fully by Brown, 1957; Doudoroff and Warren, 1962; Fry, 1960; Tarzwell, 1957; and in Water Quality Criteria, 1968. No information was found on carbon dioxide enhancement of the toxicity of chemicals, but when carbon dioxide is present in amounts sufficient to alter pH, this is a distinct possibility.

Natural environmental factors that may affect chemical toxicity directly or indirectly by contributing to water quality changes are:

(1) Air temperature – contributes to water temperature

(2) Solar irradiation and cloud cover – affects surface evaporation rate and water temperature as well as varying incident ultraviolet which may photooxidize chemicals in water

(3) Precipitation – diluting factor

(4) Wind speed and direction – affects atmospheric O_2 uptake of water by surface roiling and also causes varied rates of mixing

(5) Solids and rock substrata – provide dissolved chemicals that primarily constitute the chemical make-up of water

(6) Plant and animal detritus present in a body of water and from drainage areas – provide suspended and dissolved solids and nutrients.

Another important part of the environment that may affect chemical toxicity but not one created by nature, is the extremely wide diversity of water pollutants added to natural waters by man. Synergistic or antagonistic effects can and do occur in dilute chemical concentrations. Mixed pollutants are discussed briefly in the section Industrial Wastes.

SECTION X

INDUSTRIAL WASTES

The problem of maintaining desirable water quality increases with advancing technological development. One of the most serious water quality problems facing industry with respect to effluent discharges is the effect of toxic wastes on aquatic life. The many substances carried in solution and suspension determine whether water will be suitable for supporting aquatic organisms. Chemical contents of some wastes may be freely soluble or miscible in water, such as acids, alkalies, organic solvents, etc.; or nonsoluble, such as slurries from mining operations, soil washings, or wood pulp fibers. Adverse effects may be direct and immediate or they may be chronic and deleteriously affect the environment only gradually over a long period of time. Mixed, the wastes may be synergistic or they may reduce the damaging effects each would have individually (Garrett, 1957; Keup, et al, 1967; and Neel, 1963).

Complex wastes such as pulp mill effluents, wastes from oil refineries, and chemical plants are neither constant in content nor in concentration and this further complicates tests to determine their toxicities. Not only will a waste vary in toxicological and chemical characteristics from day to day, but also within any given day variations will occur due to process changes, raw materials, and end products. These wastes contain many known but often many unknown toxic substances (Clemens and Clough, 1965; Keup, et al, 1967; and National Technical Advisory Committee, 1968). Ellis in 1937 summarized the hazards of 30 common types of municipal and industrial effluents. This list was republished 30 years later by Keup, et al (1967) as shown in Table 9. No updating of this data summary or anything similar to it was found. For these reasons, less emphasis was placed in the present study on acquiring mixed effluent data. However, during the course of literature acquisition, considerable information on this subject area was obtained. These are briefly abstracted in Table 10. Although merely a token selection of papers on this subject, the abstracts serve to show the wide diversity of problems associated with industrial waste effluents.

For research to be effective, the scientist must know the materials he works with. McKee and Wolfe (1963) in their summaries of potential chemical pollutants discuss 39 chemicals as originating from textile wastes, while another (Anon., 1966) listed 386 compounds. This type of situation probably exists for most other industries. In all likelihood, even the latter listing is not complete since some process changes have undoubtedly been made since 1966. One of the first orders of business should be the establishment of listing of effluent components from industrial plants. These listings should be continually updated.

TABLE 9. USUAL FISHERIES HAZARDS OF 30 COMMON TYPES OF MUNICIPAL AND INDUSTRIAL EFFLUENTS[(a)] (ELLIS, 1937, FROM KEUP, ET AL, 1967)

	Changes in Water Affecting Fish							
		Hydrogen-Ion Concentration						
Types of Wastes	Decrease in Dissolved Oxygen	Increase in Acidity	Increase in Alkalinity	Increase in Specific Conductance	Increase in Turbidity	Increase in Ammonia	Bottom Pollution Blanket	Specific Toxic Action on Fishes
Mineral Wastes, Little Bacterial Action								
Erosion silt	None	None	None	None	Critical	None	Critical	None
Limestone sawmills	"	"	Possible	Moderate	"	"	"	"
Asbestos works	"	"	"	"	"	"	"	Possible
Mine flotation	Possible	Possible	"	"	"	"	"	Possible to critical
Coal- and iron-mine drains	"	Critical	None	"	None	"	Possible	Possible
Crude oil	"	None	"	None	"	"	Possible to critical	Possible to critical
Salt water from oil wells	None	"	Possible	Critical	"	"	None	"
Organic, Bacterial Action								
Municipal sewage	Critical	Possible	Possible	Possible	Possible	Critical	Possible to critical	Possible to critical
Dairy industries	"	Critical	None	Moderate	Moderate	Moderate	"	Possible
Packing plants	"	Moderate	"	"	"	Critical	Critical	"
Canning factories	"	Critical	Possible	"	"	"	Possible to critical	"
Breweries and distilleries	"	None to moderate	None to moderate	"	Possible	Possible	"	"
Beet sugar, pulp wastes	"	Critical	None	"	"	"	"	Possible to critical
Paper pulp	Possible to critical	Possible	Possible	Possible	"	"	Critical	Possible
Sawdust	"	"	"	"	"	"	"	"
Chemical Processes								
Coal-gas wastes	Possible	Possible	Possible	Moderate	None	Critical	Critical	Critical
Spent lubricants	"	"	None	Possible	"	None	"	Possible to critical
Metal refineries	None	"	Possible	"	Possible	Possible	Possible to critical	Critical
Laundries and wool washings	Moderate	None	Moderate to critical	Moderate	Moderate	Moderate to critical	Possible	Possible
Steffens house waste	"	"	Critical	Critical	"	None	"	Critical
Sulphite pulp	Moderate to critical	Possible	Moderate to critical	Moderate	"	Possible	Possible to critical	"
Strawbound waste	"	None	Critical	"	"	"	"	"
Chemical works (1)	None	"	"	"	Possible	"	None	"
Chemical works (2)	Possible	Critical	None	"	None	None	"	"
Tanneries	Moderate	Possible to critical	Possible to critical	"	Possible	Possible to critical	Critical	"
Dye works	Possible	None to moderate	None to moderate	"	None	None	Possible	"
Bittern liquors	None	Critical	None	Critical	"	"	None	Possible to critical
Tin-plate and wire mills	None to possible	"	"	Moderate	None to possible	"	Possible to critical	"
Starch factories	Possible to critical	"	"	"	Possible	Possible	"	"
Cloth sizing	"	Possible to critical	"	Possible	Moderate	"	"	Possible

(a) Increases in both acidity and alkalinity are noted in some cases, due to the fact that two or more kinds of effluents are mixed, with one predominating at times, and to changes which take place in the stream after the effluent is added.

TABLE 10. GENERAL COMMENTS ON SELECTED INDUSTRIAL EFFLUENTS

Type of Waste	Remarks	Reference
General		
Industrial wastes	A discussion of methods for studying toxicities of industrial wastes.	Heukelekian (1948)
Organic wastes	Bottom communities found in streams show characteristics reactions to pollution, i.e., grossly polluted streams contain tubificid and chironomids, etc. Various streams in New Zealand were surveyed.	Hirsch (1958)
Unspecified chemical waste	A complex chemical waste containing such toxicants as fluorides, arsenic, copper, zinc, tin, lead, and SO_2 was shown to lower pH and cause fish kill at a loading of about 0.5% of the waste in seawater at pH 5.5 and lower. Maximum toxicity occurred when superphosphate was being produced.	Chanin and Dempster (1958)
Industrial wastes	Fifty percent reduction in photosynthesis in kelp resulted from exposures to the following chemicals in four days: Inorganic Mercury 0.05 ppm Copper 0.1 ppm Nickel 2.0 ppm Chromium 5.0 ppm Chlorine 5.10 ppm Zinc 10.0 ppm Organic Sodium pentachlorophenate 0.3 ppm Zephiran chloride 1.0 ppm Sodium dodecyl sulfate 5-10 ppm Cresols 5-10 ppm Phenol 10.0 ppm Emulsified fuel oils 10-100 ppm	Clendenning and North (1960)
Organic wastes	Evaluation was made of the various approaches to the problems of organic pollution in tidal estuaries.	Pyatt (1964)
Industrial wastes	A summary of the ways in which industrial wastes may affect aquatic life.	Neel (1963)
Organic wastes from industrial sites	Stream had DO depletion for about a 45-mile stretch with heavy loss of fish and plankton organisms.	George, et al (1966)
Industrial wastes	Methods of studying industrial wastes are described.	Jackson and Brungs (1966)
Industrial wastes	An attempt is made to estimate future industrial discharges into the Eems Estuary, The Netherlands.	Eggink (1967)
Various polluting agents in rivers	A summary of problems arising from suspended solids, toxic materials and nutrients from sewage pollution.	Patrick (1968)

TABLE 10. (Continued)

Type of Waste	Remarks	Reference
Petroleum		
Refinery wastes from:	Effects on bluegill, 24-hr TL$_m$, % vol were:	Turnbull, et al (1954)
Fractionation area	Nontoxic:	
Cracking area	31.0	
Lube oil treating area	Nontoxic:	
Paraffin treating area	37.0	
Acid plant area	3.1	
Naphtha treating area	75.0	
Fluid catalyst unit	3.1	
Sulfuric acid alkylation	0.4	
unit	29.0	
Combination unit	12.0	
Distillate tank drawoff		
Oil field brine water	Average number of aquatic species found in a stream with varying chloride concentrations was:	Clemens and Finnell (1957)
	4 – 13,000-20,000 ppm	
	6 – 10,000-13,000 ppm	
	7 – 8,000-10,000 ppm	
	8 – 4,000- 8,000 ppm	
	10 – 1,000- 4,000 ppm	
	13 – 1,000 ppm	
Oil field brine water	The 24-hr TL$_m$ of fish at various concentrations of chlorides showed a marked reduction in deaths as the concentration neared 7,000 ppm. One test at 7,000 ppm for 192 hr showed 90% survival.	Wood (1957)
Oil field brine water	*Fundulus* and *Lagodon* may survive salinities up to 2.7%. *Leistomus* did well above 2.0%.	Cole, et al (1958)
Petroleum products:	Effects on American shad, 48-hr TL$_m$ (mg/l), were:	Tagatz (1961)
Gasoline	91	
Diesel fuel oil	167	
Bunker oil	2417	
	Lethality increase was accompanied by low DO.	
Refinery effluent	Based on 24-hr TL$_m$, *Lebistes reticulatus* was most resistant fish of several tested.	Bunting and Irwing (1965)
Refinery effluent (hydrogen sulfide and phenolics)	No correlation between sulfide concentration and lethal dosage to fish was found. For phenolics, the LD$_{50}$ for goldfish was 33.1%, LD$_{50}$ for red shiners was 18.8%, and LD$_{50}$ for *Daphnia* was 19.0% lower than that for red shiners.	Clemens and Clough (1965)
Petroleum oil	Pollution resulted from an underground storage tank leak. At the beginning, the concentration in the water was 221.3 ppm and after one year, 1.4 ppm. Toxic effect was pronounced on micro-fauna in sediments.	McCauley (1966)

Note: Further references on this general subject area includes papers by Copeland and Dorris (1964), Douglas, et al (1960, 1962, 1963), Gould and Irwin (1965), Johnson (1968), Smith (1968), Tubb and Dorris (1965), Ward and Irwin (1961), and Zobell (1964).

TABLE 10. (Continued)

Type of Waste	Remarks	Reference
Pulp and Paper		
Sulfite waste liquor	Decrease in feeding rate in oysters was observed.	Galtsoff, et al (1947)
Sulfite waste	Marked avoidance by juvenile chinook salmon was observed with little or no avoidance by juvenile coho salmon.	Jones, et al (1956)
Kraft mill effluent	A 100% survival of young salmon was recorded in seawater with effluent concentration under 4.8% with adequate oxygen.	Alderdice and Brett (1957)
Sulphate waste liquor	Reduced DO in river water to 1.0 mg per liter was recorded. Prawns and *Apocryptes lanceolatus* died in 3 minutes or less when exposed to the waste liquor.	Chowdhury (1957)
Kraft mill effluent	Live car bioassays showed wastes were lethal to game fish during periods of high water temperature. In mid-July, pollution-sensitive bottom fauna decreased from 54 to 17%.	Spindler and Whitney (1960)
Paper mill effluent (chlorine)	A 13-hr L_m of 32% concentration of the effluent was obtained for *Salmo salar.*	Betts and Wilson (1966)
Paper mill effluent	Silver salmon did not avoid sulfite liquor or kraft wastes in low enough concentrations to be "safe". Toxicity data are too numerous to summarize here.	Holland, et al (1960)
Sulphite waste liquor	In fluviarum experiments, avoidance reactions were exhibited by *Phoxinus phoxinus, Leuciscus rutilus, L. idbarus, Perca fluviatilis, Coregonus nasus, Salmo salar,* and *Gasterosteus aculeatus.*	Hoeglund (1961)
Kraft mill effluent	A significant decrease in *Sphaerotilus natans* growth was accomplished by the intermittent discharge of the waste using a five- or six-day holding period with a one- or two-day release.	McKeown (1962)
Kraft mill effluent	Induced spawning in mussels *Mytilus edulis* and *M. californianus* was observed.	Breese, et al (1963)
Paper mill effluent	Maximum survival of walleye eggs above mill: On bottom 1.2%; off bottom 49.1% Maximum survival of walleye eggs below mill: On bottom 1.2%; off bottom 3.5%. The principal cause of mortality below the mill was *Sphaerotilus natans.*	Smith and Kramer (1963)
Sulfite waste	Regeneration studies of bisected planaria indicated: At 550 ppm – no regeneration occurred At 50 ppm – regeneration was 75% of control.	Eng. Science, Inc. (1964)
Pulp mill waste	Histological examination of three species of fish showed decrease in RNA, glycogen in liver, necrosis in kidney, and accelerated secretion of mucus in gills. In bivalve livers, decrease in RNA and glycogen occurred, and nuclei disappeared in kidney cells.	Fujiya (1965)

TABLE 10. (Continued)

Type of Waste	Remarks	Reference
Pulp and Paper (Continued)		
Sulfite wastes	It was not clearly demonstrated that sulfite waste in the area studied was the only cause of deaths of oysters, but it was concluded that the amounts were sufficient to cause stresses which may have long-term adverse effects.	Woelke (1965)
Neutralized kraft process effluents:	Effects on guppies were: 96-hr TL_m, % vol of effluent =	Howard and Walden (1965)
Brown stock screening and deckering	51.3	
Recausticizing	92.5	
Bleach plant acid sewer	29.5	
Bleach plant caustic sewer	41.1	
Neutralized whole effluent	52.5	
Unneutralized whole effluent	9.2	
Neutralized kraft pulp bleach waste	Reduced growth in sockeye and pink salmon alevins was found in concentration of 1/10 to 1/20 the average 96-hr TL_m.	Servizi, et al (1966)
Kraft effluent	A 75% concentration was required to kill 100% of *Salmo salar* in less than 10 hr.	Betts, et al (1967)
Sewage		
Sewage	This is a summary of the problems of toxic materials and nutrients from sewage pollution.	Lackey (1958)
Sewage	A 10% concentration caused reduction on photosynthetic capacity of kelp. A concentration of 1% gave no such indication.	Clendenning and North (1960)
Sewage	Flagellates, protozoa, diatoms, and filamentous green algae showed highest sensitivity to pollution while rotifers, *Sarcodina*, and Volvocales were most tolerant.	Farmer (1960)
Sewage	A resume of sewage pollution of streams and beaches on Oahu.	Lam (1964)
Sewage	Low surface productivity at point of discharge was observed. Increase in productivity downstream in about 6 hr was recorded with maximum values in about 10 hr. This was followed by a decrease toward normal levels.	Calif. State Water Quality Control Board (1965)
Sewage	In samples of surface water from marine stations, the numbers of *Escherichia coli* depended primarily on the amount of sewage and direction of flow. Results varied enormously.	Bonde (1967)

TABLE 10. (Continued)

Type of Waste	Remarks	Reference
Suspended Solids		
Suspended mineral solids	Concentrations of 90 to 810 ppm made trout more susceptible to other adverse factors in the environment.	Herbert and Merkens (1961)
China-clay suspended waste	Concentrations of 1000 ppm reduced abundance of brown trout in an otherwise unpolluted stream. Suspensions of 60 ppm had no observable adverse effects.	Herbert, et al (1961)
Suspended solids	Laboratory experiments did not indicate that suspensions of 30 ppm kaolin and diatomaceous earth and suspensions of 50 ppm wood fiber and coal-washery wastes make well-grown trout more susceptible to disease.	Herbert and Richards (1963)
Pulpwood fibers	Significant changes occurred in blood of fathead minnows exposed to wood fibers. Increased hematocrit was highest for conifer groundwood, followed by aspen groundwood, kraft conifer, and sulfite conifer.	Smith, et al (1965)
Suspended conifer groundwood	Survival of walleye fingerlings decreased when DO was reduced.	Smith and Kramer (1965)
Suspended groundwood	Rainbow and brown trout eggs survived in suspensions of 60, 125, and 200 ppm conifer groundwood. Trout alevins survival rate decreased to a minimum of 0 in 250 ppm. The growth rate of survivors was reduced.	Smith and Kramer (1965)
	Fathead minnows which were held for 96 hr in 0 to 2000 ppm of aspen groundwood showed no effects to this exposure. A similar series run in conifer groundwood showed increased mortality at 738 and 2000 ppm.	
Conifer groundwood fiber	Reduced growth was recorded for walleye fingerlings held in concentrations of 50 to 150 ppm.	Smith, et al (1966)
Suspended wood fibers	Walleye eggs survived at concentrations of 250 ppm.	Kramer and Smith (1966)
Paper fiber sludge	Low DO, high CO_2, and presence of dissolved sulfides in streams were recorded.	Colby, et al (1967)
Miscellaneous		
Unspecified chemical waste	A complex chemical waste containing such toxicants as fluorides, arsenic, copper, zinc, tin, lead, and SO_2 was shown to lower pH and cause fish kill at a loading of about 0.5% of the waste in seawater at pH 5.5 and lower. Maximum toxicity occurred when superphosphate was being produced.	Chanin and Dempster (1958)
Electroplating wastes	A midgefly, *Cricotopus bicinctus*, survived and matured in concentrations of chromium as great as 25 ppm, in copper at 2.2 ppm, and in cyanides at 3.2 ppm.	Surber (1959)

TABLE 10. (Continued)

Type of Waste	Remarks	Reference
Miscellaneous (Continued)		
Spent still liquors from coal distillation	Indications are that the toxicity of spent still liquors from the distillation of coal is mainly due to ammonia and monohydric phenols.	Herbert (1962)
Smelter wastes	Near the smelter, the aquatic flora and productivity was greatly reduced. *Leptodictyum riparium* and *Eleocharis acicularis* v. *submersa* appeared to be the most tolerant organisms.	Gorham and Gordon (1963)
Acid mine drainage	Twenty states have streams affected by acid mine drainage. Pennsylvania has 2,906 miles of streams polluted with acid mine drainage, Virginia has 1,150, and Kentucky has 590. The remaining states have less than 300 each.	Kinney (1964)
Alkaline water	The pH of water passing through asbestos-cement pipeline was increased to 9.5 with no immediate lethal effect on salmonids.	Sprague (1964)
Lurgi process wastes (bituminous coal)	Treatment of effluent reduced permanganate value to less than 50 ppm and BOD to less than 25 ppm. The residual organic matter had little direct toxic effect on fish.	Cooke and Graham (1965)
Uranium mill wastes	The radioactive element in this study was radium; the nonradioactive materials included sulfates, nitrates, chlorides, manganese, iron, lead, arsenic, and various organics. These wastes were important in limiting aquatic biota below uranium mills. Changes in composition of the wastes and water flow make it difficult to calculate the radioactive and nonradioactive components of the mill wastes.	Sigler, et al (1966)
Coal washer wastes	As long as the coal washer wastes were intermittent, there was little effect on biological productivity.	Charles (1966)
Uranium mine	The effluent did not appear to have any adverse effect on plankton, periphyton, benthos, and fish species other than trout (reduced numbers).	Mitchum and Moore (1967)
Landfill pollution	Groundwater was polluted with CO_2 from decomposing refuse in a landfill.	Bishop, et al (1967)
Sulfuric acid water	Considerable reduction in survival percentage was found in herring eggs and embryos at dilutions of 1:32,000.	Kinne and Rosenthal (1967)
Photographic wastes	Common chemicals found in these wastes are potassium ferricyanide, sodium ferricyanide, boron, chromium, and sodium thiosulfate. Release of this type of waste into streams and the Los Angeles sewage system is discussed.	Hennessey and Rosenberg (1968)

SECTION XI

EXTRACTED DATA – THE EFFECT OF CHEMICALS ON AQUATIC BIOTA

Extracted information from originally published data are divided in two sections, both alphabetically arranged by chemical name. One section (Appendix A) concerns listing by chemical name, and the other a similar listing by commercial designation (Appendix B). In all cases, the chemical names and names (common or scientific) of organisms designated by the authors were used in this compilation. None of the nomenclature was changed or corrected in any manner, e.g., when authors used the common name of a fish, this and this alone was used. The abbreviations and other designations are discussed later in this report section and described in footnotes to the Appendices. In using the data compilations, care should be exercised in searching varied alternative names for a given compound.

Since many papers contained large amounts of data, the most significant toxicity level was chosen for inclusion in this compilation. In most cases, data presented at 96-hr TL_m (designated T4: T = TL_m or TL_{50}, and 4 = four days or 96 hours) were selected when available. With few exceptions, the T value at 4 days was lower than the values for 1 or 2 days. The T4 value is generally accepted as a realistic indication of toxic effect and the best one to use (lacking data from chronic studies) in estimating safe levels for effluent release. T1 or T2 data were usually not included unless these were the only data given. A and C following these designations indicate acute or chronic bioassays, respectively. Since the data are presented as brief summaries, the reader is referred to the original report for additional information. When EC_{50}, LC_{50}, and LD_{50}*, were known or described as being concerned with lethal effects, these abbreviations were judged to be essentially the same as TL_m or TL_{50} and designated as such (T) in the data extracts for consistency. We acknowledge that this is not standard practice, and that there are important differences in these designations.

The conditions noted by the researchers are designated by lower case letters. When the conditions were controlled, these letters were underlined. In some cases, the authors briefly referred to previous papers as a simple means for describing experimental conditions. No underlines were made in these instances, although in all likelihood some conditions were controlled.

Comments, in general, are brief, with the expectation that interested readers would consult the original article for further information.

Since the chemical nature of most industrial effluents is very complex and seldom analyzed or reported, there is little information on the effect of mixed effluents or mixtures of chemicals in the data presented. For this reason, this document must be described merely as pertaining to the effect of single chemicals or simple mixtures of chemicals on aquatic life.

There was no attempt to extract data from various reviews available, since these rarely contained descriptive information concerning experimental conditions. Among others, the reader is referred to:

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*EC_{50} = median effective concentration, LC_{50} = median lethal concentration, and LD_{50} = median lethal dosage.

American Public Health Assoc. (1960)
Anon. (1968)
Aquatic Life Advisory Committee (1955, 1960, 1967)
Averett and Brinck (1960)
Beak (1958)
Bick (1963)
Breidenback, et al (1967)
Breidenback and Lichtenberg (1963)
Brown (1961)
Burdick (1965)
Butcher (1959)
Butler (1966)
Buzzell, et al (1968)
Byrd (1960)
Carter (1962)
Cope (1963, 1965)
Cope and Springer (1958)
Cottam (1961)
Delaporte (1958)
Dewey (1958)
Doudoroff (1951)
Doudoroff and Katz (1950, 1953)
Faust and Aly (1964)
Ferguson (1967)
Ferguson, et al (1966)
Fromm (1965)
Fruh, et al (1966)
Ganelin, et al (1964)
George (1959)
Graham (1960)
Hawkes (1963)
Henderson and Tarzwell (1957)
Hirsch (1958)
Hoffman (1960)
Holden (1964, 1965)
Hughes and Davis (1967)
Hunt (1965)
Hynes (1966)
Ingram and Towne (1960)
Jackson (1966)
Johnson (1968)
Johnson, et al (1967)
Jones (1964)
Kerswill, et al (1960)
Keup, et al (1966, 1967)
King (1968)
Langer (1964)
Lawrence (1962)
Lloyd (1964, 1965)
MacMullen (1968)
Mackenthum and Ingram (1962, 1964)
Malina (1964)
McKee and Wolfe (1963)
McFarland (1959)
Moore (1967)
National Technical Advisory Committee (1968)
Neel (1963)
Newsom (1967)
Nicholson (1959, 1967)
Nicholson, et al (1964)
Patrick (1968)
Powers (1918)
Reymonds (1962)
Rudolphs, et al (1950)
Ryckman, et al (1966)
Schoettger (1967)
Skidmore (1964)
Snow (1958)
Spiller (1961)
Sproul and Ryckman (1963)
Surber and Taft (1965)
Tarzwell (1959, 1962)
Water Pollution Control Federation Research Committee (1958-1968)
Weaver, et al (1965)
Webb (1961)
Wilson (1968)

Doudoroff (1951) states that certain references with literature summaries are particularly helpful in providing pertinent information published before 1954 on water pollutants toxic to fish. These references are:

Redeke, H. C., "Report on the Pollution of Rivers and Its Relation to Fisheries", Rapp. Conseil Permanent Intern. Exploration Mer, 43, 1 (1927).

Steinmann, P., "Toxikologie der Fische", Handbuch Binnenfischerei Mitteleuropas (Germany), 6, 289 (1928).

Helfer, H., "Giftwirkungen auf Fishe; ihre Ermittelung der Versuche und die Bewertung der Ergebnisse", Kleine Mitt. Mitglied. Ver Wasser-Boden-u. Lufthyg., 12, 32 (1936).

Cole, A. E., "The Effects of Pollutional Wastes on Fish Life", in a Symposium on Hydrobiology, University of Wisconsin Press, Madison, Wisconsin, 241 (1941).

Southgate, B. A., "Treatment and Disposal of Industrial Waste Water", Department of Scientific and Industrial Research, London, England, 23 (1948).

Harnisch, O., "Hydrophysiologie der Tiere", in "Die Binnengewasser", Vol. 19, Ed. A. Thienemann, Schweizerbart'sche, Erwin Nagele, Stuttgart, Germany (1951).

"Water Quality Criteria", California Water Pollution Control Board, Pub. No. 3, Sacramento, California (1952). (Also, Addendum No. 1, 1954, and Pub. No. 3, 1963).

Not to demean past contributions from ecological investigators, but rather to suggest how the data they develop in the future can be made more valuable for engineering application, it may be stated that problems of interpretation encountered in this review would be minimized or eliminated by the following:

- Positive identity of chemicals under test
- Precise description of test organisms
- Use of standard test methods, where applicable, or full details of procedure if standard methods are not used
- Closer definition and control of test conditions.

Apparent differences in results among investigators of the same chemical on the same fish species may have resulted from different methods of handling specimens prior to and during tests, different stages in the life cycle of specimens, variations in physical and chemical properties of the water, excursions in time-temperature pattern of exposures to the chemical, and different methods of evaluating effects.

We believe the manner in which this report is compiled will serve the industrial community and others as well. Since each reader will undoubtedly have a specific applied situation for using the data, there was no attempt to summarize in narrative form the data for each compound. The compilation gives pertinent data for each chemical for which information was found, tempered by the comments on bioassay or field conditions, as well as providing a bibliography of the more recent information available in the literature through 1968. Additionally, a Species Index is presented in Appendix C and the chemical nature of commercial chemicals is given when available in Appendix D.

In handling large numbers of references, an occasional document may be overlooked and not included. The authors would sincerely appreciate being informed by the readers of such omissions for the principal time period covered (1958-1968). An updating effort of this report is now under consideration and will likely be completed by early 1972.

SECTION XII

SUMMARY AND CONCLUSIONS

Fish, representing one of the highest trophic levels in the aquatic environment, are the animals of choice in studying the toxicity of chemical effluents in natural waters. Their importance is further emphasized since man may be the next highest trophic level where edible fish are concerned. Furthermore, considering fish as indicator organisms, their presence probably indicates that the water in which they survive is suitable for consumption or other uses by man, except in some situations, for example, where a cumulatively toxic material is present in small amounts and the fish develop resistance to that material.

With the magnitude of pollution problems today, standard fish bioassay procedures (particularly, flow-through) are adequate for the task at hand. This is especially true for evaluation of chemicals that are acutely or immediately toxic although these procedures can also be used in studying the chronic toxicity of chemicals at sublethal levels. These standard procedures must be employed in conjunction with other evaluations, especially specific residue analyses, when a chemical or ion causes a drastic problem such as a large-scale fish kill. The chronic continuous flow exposure of fish is preferable for determining more precisely acceptable concentrations for chemical release. TL_m data should be a baseline for comparison of data from either type of evaluation. Adequate reporting of data and experimental conditions, especially water quality data, would greatly enhance the value of published information.

For field investigation of chemical toxicity in the aquatic environment, the *in situ* bioassay is desirable. Exposure of native fish or highly sensitive fish from other sources would give a better representation of the toxicity of a given chemical in a given situation. This should be supplemented with chemical analysis of the effluent in question as well as a recording of receiving water quality data. *In situ* evaluation of water from above and immediately below an effluent addition could provide an elegant proof of lack of complicity in a fish kill by a manufacturer.

With the present situation of gross pollution in many localities, study of fish responses other than lethality are of little direct utility except in cases where a chemical has long-term, sublethal effects, such as DDT and other chlorinated hydrocarbons. All such procedures would be best employed in conjunction with standard bioassays so that appropriate comparisons can be made. These procedures include:

(1) Observations of abnormal behavior
(2) Autopsy and histology
(3) Avoidance
(4) Growth retardation
(5) Radiotracers
(6) Effects on various life stages
(7) Spawning
(8) Swimming or cruising speed and oxygen consumption
(9) Blood studies
(10) Glucose transport
(11) Environment stress
(12) Thermal acclimitization
(13) Fish taste
(14) Conditioned avoidance response.

For a careful limnological approach in bioassay studies, several researchers have suggested toxicity evaluations of aquatic organisms representing at least three trophic levels of the food web. Fish would, of course, be one level. Another could be bioassay using *D. magna* and the techniques described by Anderson (1944-1946, 1948, 1960). The third type of bioassay could be with algae, using the technique of Palmer and Maloney (1955) or of Fitzgerald and Faust (1963). BOD determination by the standard method (American Public Health Association, 1967) could be another bioassay procedure. More rapid, alternative methods (e.g., STOD) are also available for estimating BOD. BOD data alone can provide a useful index of toxicity or of oxygen depletion in receiving water.

Marine bioassay utilizing various organisms primarily including fish, oyster, clams, and shrimp in a flow-through type of system lags considerably behind reports of freshwater bioassays in the amounts of data reported. The procedure is practical but could be improved upon by maintenance of water temperature, DO, and other water factors. The sensitivity of shell regrowth in bioassay and field studies of oyster *(Crassostrea virginia)*, clam *(Mercenaria mercenaria)*, and related marine mollusks to low concentrations of pesticides suggests that a bioassay using a freshwater mollusc should be developed.

Reports on field studies of pollution problems include some of the classic examples of disruption of the aquatic environment by polluting effluents and pesticide applications. Although the results of such research are irrefutable in most instances, improvement is needed in recording and reporting correlative data, e.g., water quality, weather, and other environmental factors. Collecting devices are generally adequate for their designed purposes if used by experienced field scientists, but some mechanical changes could improve collection and ease of manipulation in the field.

Evaluation in the field in a given pollution situation can yield more realistic results than evaluation by laboratory bioassay. Consider, for example, change in chemical toxicity due to seasonal temperature change. This is the reason *in situ* bioassay (using live cars or wire cages and plastic pools or raceways with suitable bioassay species in conjunction with automatic water quality monitoring) appears to be the method of choice for an individual industry to evaluate the effect of its particular effluent(s) on a given waterway.

The complex, highly interrelated factors in the aquatic environment may have profound effect on the toxicity of a chemical. Of these, the most important are temperature, dissolved oxygen, pH, turbidity (suspended solids), and water hardness. Their importance in aquatic studies and their effect on chemical toxicity were discussed in some detail.

In addition to conclusions and comments made throughout this report, the following remarks are made in direct response to the objectives outlined earlier in this report:

(1) Collect and summarize in standardized format the available information from the scientific literature. The extracted data presented in Appendices A and B show that there is a considerable lack of adequate reporting of experimental conditions concerning the effect of chemicals on aquatic life. The complexity of factors in both laboratory and field studies in aquatic biology is such that control or description of them is most difficult. The specific effects of chemicals on individual species of aquatic biota are voluminously shown in Appendices A and B in a standardized format. A Species Index (Appendix C) facilitates assembling all data for any given species. Procedural details and environmental factors important in the observation or measurement of these effects are discussed in appropriate sections of this report. Except for standard fish bioassays (static,

continuous flow, and chronic exposures) and BOD, the wide variety of procedures utilized for these studies were not discussed in detail. References are cited to allow the individual reader to obtain these procedures when needed.

(2) Review the existing information on aquatic life as it is applicable or related to the study of water pollution. The existing, more recent information on aquatic life as it is applicable or related to the study of water pollution was reviewed. Discussion of test species, lack of species variety identification, short-comings of procedural details in reporting bioassay and field results, etc., is presented in various report sections.

(3) Review the methodology used in studying the effects of chemicals on aquatic life. Similarly, a review of the more important aspects of aquatic life methodology is presented. Briefly, except for the standardized bioassays, experimental procedures vary almost directly and specifically with the number of researchers reporting data in the literature.

We believe the requirements described in the objectives for this study were fulfilled.

SECTION XIII

RECOMMENDATIONS

We recommend:

(1) Establishment of a chemical pollution effect information-analysis center as a means of continuously updating the information summarized here. This report has shown the large volume of information available on the effects of chemicals on aquatic life. The amount of information is unwieldy and difficult to work with. A computerized information-analysis center would be capable of quickly identifying all pertinent data and would allow rapid preparation of reports summarizing data on any chemical or group of chemicals in given situations for various aquatic biota. Establishment of a prototype information center on analytical methodology related to the aquatic environment is now in progress at Battelle's Columbus Laboratories. Bioassay data not now published but held by individual manufacturers could be anonymously submitted for inclusion into the information pool. Only data obtained by a standard procedure or a well-described one would be included at the discretion of EPA and center personnel. We believe the data base would be greatly expanded in this manner. The information content of this prototype center is to be continually updated so that it would always be current as well as immediately responsive as required.

As data are accumulated, the chances for predicting potential problems by mathematical modeling and simulation of the effect of chemicals on aquatic life will be improved. This report should provide a sound base for pursuing this approach.

(2) Preparation of listings of chemical constituents present in effluents by cooperative input from the chemical industry. Data inputs could be submitted anonymously. The listings should be continuously updated and made easily available to anyone who requests updated copies.

(3) Development of a standard pattern of laboratory evaluations, not limited to but primarily based on fish bioassay, for estimating more accurately the effect of chemicals on aquatic life. Data from such evaluations could then be used in mathematical modeling studies which would be used for predicting chemical toxicity under widely varied environmental conditions.

(4) Development of *in situ* field bioassay procedures for more realistic results than those obtained from laboratory bioassays.

We suggest that researchers publishing in this field be encouraged to positively identify the chemicals evaluated; to precisely describe test organisms; to use standard methods, if possible, or to fully describe experimental procedures; and to more closely define and control experimental conditions. This improved reporting would greatly enhance the utility of the data, and allow more precise development of multivariate analyses and mathematical modeling for predictive assessments of chemical pollution problems.

SECTION XIV

BIBLIOGRAPHY

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SECTION XV

APPENDICES

A. EXTRACTED DATA FROM ORIGINAL PAPERS – CHEMICALS AND MIXTURES OF CHEMICALS

B. EXTRACTED DATA FROM ORIGINAL PAPERS – COMMERCIAL CHEMICAL PRODUCTS

C. SPECIES INDEX FOR APPENDICES A AND B

D. IDENTIFICATION OF COMMERCIAL CHEMICALS

Note: Both scientific and common names should be checked for complete retrieval of information for a given organism.

APPENDIX A

EXTRACTED DATA FROM ORIGINAL PAPERS – CHEMICALS AND MIXTURES OF CHEMICALS

Note: Names of chemicals and organisms are as given by the various authors. Readers should search for alternate, common, and/or scientific names of both chemical and aquatic species; and refer to report section on Extracted Data for further discussion of this appendix.

Footnotes for Appendices A and B:

(1) Letters represent:
B = bioassay, used in combination with S = static, CF = continuous flow, A = acute, and CH = chronic.
L = laboratory bioassay.
BOD = biochemical oxygen demand.
F = field study, used in combination with R = river, stream, creek, etc., L = lake or pond, M = marine, E = estuarine, and O = other (port facility, flooded area, etc.).

(2) Field location is indicated by abbreviation of the state or country.

(3) The number indicates ppm (mg/l), unless otherwise indicated by appropriate designations or (O). The letters within parentheses following indicate T = TL_m, K = kill, SB = sublethal effects, NTE = no toxic effect, or O = other. The number following these indicates the time in days at which observations were made. EC_{50}, LC_{50}, and similar designations for 50 percent lethality were all considered as TL_m and designated as such. The numbers within parentheses following these designations indicate the time in days when the effect was observed.

(4) The following indicate (when underlined the variable was controlled):
a = water temperature
b = ambient air temperature
c = pH
d = alkalinity (total, phenolphthalein or caustic)
e = dissolved oxygen
f = hardness (total, carbonate, Mg, or CaO)
g = turbidity
h = oxidation-reduction potential
i = chloride as Cl
j = BOD, 5 day; (J) = BOD, short-term
k = COD
l = nitrogen (as NO_2 or NO_3)
m = ammonia nitrogen as NH_3
n = phosphate (total, ortho-, or poly)
o = solids (total, fixed, volatile, or suspended)
p = CO_2

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Chemical	Organism	Bioassay or Field Study$^{(1)}$	Field Location$^{(2)}$	Toxicity, Active Ingredient, ppm$^{(3)}$	Experimental Variables Controlled or Noted$^{(4)}$	Comments	Reference (Year)
Acetaldehyde	*Lagodon rhomboides*	BSA	–	70.0 (T1A)	a	Aerated sea water was used.	Daugherty and Garrett (1951)
Acetaldehyde	*Lagodon rhomboides*	BSA	–	70.0 (T1A)	–	Experiments were conducted in aerated salt water.	Garrett (1957)
Acetaldehyde	Sewage organisms	BOD	–	230 (TC_{50})	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Acetaldehyde	*Lepomis macrochirus*	BSA	–	53.0 (T4A)	a c d e	All fish were acclimatized for 2 weeks in a synthetic dilution water.	Cairns and Scheier (1968)
Acetaldehyde	*Nitzschia linearis* *Lepomis macrochirus*	BSA	–	236.6-249.1 (T5A) 53.0 (T4A)	a c e	The purpose of this experiment was to determine whether there was a constant relationship between the responses of these organisms. From the data presented, there was no apparent relationship of this type. Therefore the authors advise that bioassays on at least 3 components of the food web be made in any situation.	Patrick, et al (1968)
Acetaldehyde (a)-acetone (b)-copper (c)-acetic acid (d) mixture	*Lepomis macrochirus*	BSA	–	(a) 5.2 (T4A) (b) 5.2 (T4A) (c) 1.04 (T4A) (d) 26.0 (T4A)	a c d e	All fish were acclimatized for 2 weeks in a synthetic dilution water.	Cairns and Scheier (1968)
Acetamide	*Gambusia affinis*	BSA	–	26,300 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Acetanilide	Sewage organisms	BOD	–	(NTE)	–	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Acetic acid	*Daphnia magna*	BSA	–	150 (O)	a e	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)

Acetic acid	*Semotilus atromaculatus*	BSA	–	100 to 200 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
Acetic acid	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (0)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T=toxic, NT=nontoxic, PT= partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – NT Ma – NT So – NT Cv – NT Gp – NT Np – NT	Palmer and Maloney (1955)
Acetic acid	*Gambusia affinis*	BSA	–	251 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Acetic acid	*Ictalurus punctatus*	BSA	–	388 (T2A) 629 (K2)	a c f i	The experiment was conducted at 77 C.	Clemens and Sneed (1958)
Acetic acid	Channel catfish (fingerlings)	BSA	–	446 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Acetic acid	*Culex* sp *(larvae)* *Daphnia magna* *Lepomis macrochirus*	BSA	–	1500 (T1A) 47 (T1A) 100 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Acetic acid	*Lepomis macrochirus*	BSA	–	75 (T4A)	a c d e	All fish were acclimatized for 2 weeks in a synthetic dilution water.	Cairns and Scheier (1968)
Acetic acid	*Nitzschia linearis* *Lepomis macrochirus*	BSA	–	74 (T5A) 75 (T4A)	a c e	The purpose of this experiment was to determine whether there was a constant relationship between the responses of these organisms. From the data presented, there was no apparent relationship of this type. Therefore the authors advise that bioassays on at least 3 components of the food web be made in any situation.	Patrick, et al (1968)
Acetic acid (a)-acetaldehyde (b)-acetone (c)-copper (d)-mixture	*Lepomis macrochirus*	BSA	–	(a) 26.0 (T4A) (b) 5.2 (T4A) (c) 5.2 (T4A) (d) 1.04 (T4A)	a c d e	All fish were acclimatized for 2 weeks in a synthetic dilution water.	Cairns and Scheier (1968)

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Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Acetone	*Daphnia magna*	BSA	–	9280 (O)	a e	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Acetone	*Gambusia affinis*	BSA	–	13,000 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Acetone	Sewage organisms	BOD	–	(NTE)	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Acetone	*Daphnia magna*	BSA	–	10 (T2A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Acetone	*Lepomis macrochirus*	BSA	–	8300 (T4A)	a c d e	All fish were acclimatized for 2 weeks in a synthetic dilution water.	Cairns and Scheier (1968)
Acetone	*Nitzschia linearis* *Lepomis macrochirus*	BSA	–	11,493 to 11,727 (T5A) 8,300 (T4A)	a c e	The purpose of this experiment was to determine whether there was a constant relationship between the responses of these organisms. From the data presented, there was no apparent relationship of this type. Therefore the authors advise that bioassays on at least 3 components of the food web be made in any situation.	Patrick, et al (1968)
Acetone (a)-copper (b)-acetic acid (c)-acetaldehyde (d)-mixture	*Lepomis macrochirus*	BSA	–	(a) 5.2 (T4A) (b) 1.04 (T4A) (c) 26.0 (T4A) (d) 5.2 (T4A)	a c d e	All fish were acclimatized for 2 weeks in a synthetic dilution water.	Cairns and Scheier (1968)
Acetonitrile	*Pimephales promelas*	BSA	–	(H+S) 1000 (T4A)	c d e f	(H) Value in hard water (S) Value in soft water	Henderson, et al (1960)
	Lepomis macrochirus			(S) 1850 (T4A)			
	Lebistes reticulatus			(S) 1650 (T4A)		The chemical caused no change in flavor of the cooked bluegill.	
2-acetylamino-fluorene (AAF)	Zebrafish	BSA	–	(O)	–	The results of this investigation show that definite changes in the concentration of RNA and glycogen accompany the cellular disorganization in abnormal embryos induced by AAF. In embryos treated with AAF, there was a consistent decrease of RNA content of the liver, nervous tissue, sense organs, and the mucosal lining of the digestive tract. In general, this only occurred when concentrations of the chemical exceeded 0.03 percent.	Hisaoka (1958)

Acetyl phenylhydrazine	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75-ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
Acrolein	Sewage microorganisms	BOD	–	1.5 (O)	–	The chemical was studied as to how low levels (ppm) may affect BOD in domestic sewage. The chemical was toxic to sewage microorganisms at the level stated. To acclimated organisms the toxicity was 18 ppm.	Oberton and Stack (1957)
Acrolein	Oyster	BCF	–	0.055 (O)	a	The value reported is a 96-hr EC_{50} (decreased shell growth).	Butler (1965)
Acrolein	*Fundulus similis* (juvenile)	BSA	–	0.24 (O)	a	Water temperature was 21 C. The figure reported is a 48-hr EC_{50}.	Butler (1965)
Acrolein	*Penaeus aztecus*	L	–	0.19 (O)	a	Toxicant chemicals were evaluated in seawater at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality.	Butler (1965)
Acrolein	*Crassostrea virginica*	BCFA & BSA	–	0.05 (O)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
	Penaeus aztecus			0.1 (O)			
	Fundulus similis			0.24 (T2CFA)			
	Phytoplankton						
Acrolein	Salmon	BSA	–	0.08 (T2A)	–	Data are given as LC_{50}.	Bohmont (1967)
Acrylaldehyde (acrolein)		BSA	–		a	Experiments were conducted in standing water. Results were rated on a scale of 0 to 10, 0 standing for no toxic effect and 10 signifying a complete kill. Evaluation was based on visual observation of the plant response at weekly intervals for 4 weeks.	Frank, et al (1961)
	Potamogeton modosus			100 (O)		Injury rating of 8.3.	
	Potamogeton pectinatus			100 (O)		Injury rating of 9.6.	
	Elodea canadensis			100 (K4wk)			
Acrylonitrile	*Lagodon rhomboides*	BSA	–	24.5(T1A)	a	Aerated seawater was used.	Daugherty and Garrett (1951)
Acrylonitrile	*Lepomis macrochirus*	BSA & CH	–	0.05-0.1 (100% KS) 0.1-1.0 (100% KCH)	a	Additional data are presented for less than 24 hr.	Renn (1955)
	Pomoxis annularis			6.0-10.0 (100% KCH)			

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Acrylonitrile	*Lagodon rhomboides*	BSA	–	24.5 (T1A)	–	Experiments were conducted in aerated salt water.	Garrett (1957)
Acrylonitrile	*Pimephales promelas*	BSA	–	(S) 18.1 (T4A) (H) 14.3 (T4A)	c d e f	(H) Value in hard water (S) Value in soft water The chemical did not change the flavor of the cooked bluegill.	Henderson, et al (1960)
	Lepomis macrochirus			(S) 11.8 (T4A)			
	Lebistes reticulatus		–	(S) 33.5 (T4A)			
Adipic acid	*Lepomis macrochirus*	BSA	–	330 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Adiponitrile	*Pimephales promelas*	BSA	–	(S) 1250 (T4A) (H) 820 (T4A)	c d e f	(H) Value in hardwater (S) Value in softwater	Henderson, et al (1960)
	Lepomis macrochirus			(S) 720 (T4A)			
	Lebistes reticulatus			(S) 775 (T4A)		The chemical produced no change in the flavor of the cooked bluegill.	
Alkyl aryl bromide	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – NT Ma – T So – NT Cv – NT Gp – NT Np – NT	Palmer and Maloney (1955)
Alkyl-dimethyl-ammonium chlorides	*Cylindrospermum licheniforme (Cl)* *Gleocapsa* sp (G) *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzchia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – PT (7) G – NT So – PT (7) Cv – PT (3) Gp – NT Np – PT (3)	Palmer and Maloney (1955)
Alkyl sulfate	*Pimephales promelas (juveniles)*	BSA	–	(S) 5.1-5.9 (T1-4A) (H) 5.9-6.1 (T1-4A)	a c d f	Syndets and soaps were of nearly equal toxicity in soft water (S) but syndets were approximately 40X more toxic than soap in hard water (H). The surfactant rather than the builder contained the toxicant.	Henderson, et al (1959)

Alkyl benzene sulfate – See ABS in Appendix B.

Aluminum ammonium sulfate	*Daphnia magna*	BSA	–	190 (O)	a e	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Aluminum chloride	*Gambusia affinis*	BSA	–	135 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Aluminum chloride	*Daphnia magna*	BSA	–	<6.7 (S)	a	Lake Erie water was used as diluent. Toxicity given as threshold concentration producing immobilization for exposure periods of 64 hr.	Anderson (1948)
Aluminum nitrate	*Gasterosteus aculeatus*	BSA	–	0.07 (K10)	–	Solutions were made up in tap water. 3.0 to 5.0 cm stickleback fish were used as experimental animals. This paper points out that there is a marked relationship between the toxicity of the metals and their solution pressures. Those with low solution pressures were the most toxic.	Jones (1939)
Aluminum potassium sulfate	*Daphnia magna*	BSA	–	206 (O)	a e	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Aluminum sulfate	*Daphnia magna*	BSA	–	136 (O)	a e	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Aluminum sulfate	*Micropterus salmoides* *Lepomis machrochirus* Goldfish	BSA	–	100 (O) 100 (O) 100 (O)	a c f p i	The disposal of cannery wastes frequently involves the use of chemicals for treatment purposes. Ferrous sulphate, alum, and lime are used in chemical coagulation; sodium carbonate for acidity control in biological filters; and sodium nitrate in lagoons for odor control. Lye (sodium hydroxide) peeling of certain fruits and vegetables is not uncommon. These chemicals, in whole or part, are discharged in most cases to a stream. The concentrations listed permitted all fish to survive indefinitely.	Sanborn (1945)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Aluminum sulfate	Sewage organisms	BOD	–	18.0 (O)	–	Various metal salts were studied in relation to how they affected the BOD of both raw and treated sewage as well as how they affected the processing of sewage in the treatment plant. BOD was used as the parameter to measure the effect of the chemical. The chemical concentration cited is the ppm required to reduce the BOD values by 50%. This chemical was tested in an unbuffered system.	Sheets (1957)
Aluminum sulfate	*Gambusia affinis*	BSA	–	240 (T2A)	a c d e g	The effect of turbidity on the toxicity on the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
p-aminodi-ethylaniline HCl	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
p-aminodi-methylaniline	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	Comment same as above.	Fitzgerald, et al (1952)
p-aminodi-methylaniline HCl	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	Comment same as above.	Fitzgerald, et al (1952)
η-(3-amino-propyl) rosinamine D diacetate (28 percent active)	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – T (14) Ma – T So – PT Cv – T (14) Gp – T Np – T	Palmer and Maloney (1955)
p-aminophenol	*Daphnia magna*	BSA	–	2 (K2A)	a	An attempt was made to correlate the biological action with the chemical reactivity of selected chemical substances. Results indicated a considerable correlation between the aquarium fish toxicity and antiautocatalytic potency of the chemicals in marked contrast to their toxicity on systemic administration.	Sollman (1949)
4-amino-m toluene-sulfonic acid	*Gambusia affinis*	BSA	–	410 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)

Ammonia	Trout	BSA	–	(O)	a e	No quantitative data are reported. 30 ppm of nitrogen was added as ammonium chloride. Carbon dioxide in concentrations up to 30 ppm reduced the toxicity of the ammonia by lowering the pH of the water. Concentrations of 60 ppm of CO_2 were toxic but not lethal when the concentration of dissolved oxygen was low. A concentration of 240 ppm of CO_2 was lethal to trout in little more than one hour.	Herbert (1955)
Ammonia	*Pimephales promelas*	BSA	–	(H) 8.2 (T4A) (S) 5.9 (T4A)	c d e f	(H) Value in hardwater (S) Value in softwater	Henderson, et al (1960)
Ammonia (unionized)	*Salmo gairdnerii*	BSA	–	0.4 (T1A)	a b c d e	Toxicity of ammonia or of ammonium salts was increased by a rise in pH value from 7.0 to 8.2. Toxicity of such solutions to fish apparently depended upon the concentration of the unionized ammonia molecule present. Variation was attributed to the increase in the concentration of free carbon dioxide at the gill surfaces.	Lloyd and Herbert (1960)
Ammonia	*Salmo gairdnerii*	BSA	–	100-200 (O)	a c e p	The major factor determining the toxicity of ammonia is the pH of the water. Temperature, dissolved oxygen, and bicarbonate alkalinity are also important. Only unionized ammonia was toxic to fish. At a pH of 7.0 the threshold value for ammonia ranges between 100 and 200 ppm (as N), depending on the bicarbonate hardness.	Lloyd (1961)
Ammonia	*Gambusia affinis*	BSA	–	(O)	a c d i	The pH value and temperature had a marked effect upon the toxicity of ammonia solutions. As the pH was raised, the toxicity increased markedly. The concentration of unionized ammonia present in each test was calculated using the mean temperature and the pH value. The absence of toxic action by tests at a total ammonia concentration equivalent to 120 mg/IN.	Hemens (1966)
Ammonia	Green sunfish	BSA	–	(O)	–	Ammonia or ammonium hydroxide was found to repel fish at 8.5, 10, and 20 mg/l. At 1.7 mg/l no repellency was noted. In concentrations of 10 and 22 mg/l, ammonia killed the fish in repellent studies before they had the opportunity to move out of the area containing the substance.	Summerfelt and Lewis (1967)
Ammonia	*Abramis brama* *Perca fluviatillis* *Rutilis rutilis* *Scardinius erythrophthalmus* *Salmo gairdnerii*	BCF	–	0.41 (T7CF) 0.29 (T7CF) 0.35 (T5CF) 0.36 (T6CF) 0.41 (T2CF)	a c d e f	The T at LC_{50} values are asymptotic values of undissociated ammonia (mgN/l). Additional data are presented.	Ball (1967)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Ammonia	*Salmo gairdneri*	BSA	–	(O)	a c l m	After 24-hr exposure the mean blood levels for total ammonia showed a direct linear correlation with ambient ammonia and ranged from 38 to 70 g/ml. Fish exposed to 0-1 g/ml nonionic ammonia had mean blood levels which ranged from 0.6 to 1.3 g/ml. Ammonia in concentrations up to 10 g NH_3/ml was found to have no significant effect on the ability of hemoglobin to combine with oxygen in vitro.	Fromm and Gillette (1968)
Ammonia	*Salmo gairdneri*	BSA	–	34-47 (T2A)	a c d e f o	The concentration killing a half batch of fish in 2 days provides a reasonable estimate of the threshold concentration. The lethality of this chemical depends upon all the experimental variables listed and the concentration of undissociated ammonia which is present.	Brown (1968)
Ammonia (unionized)	*Salmo gairdnerii*	FR	Stevenage Herts.	(O)	a c e l m	Survival of rainbow trout in concentrations of unionized ammonia in the range of 0.86-1.96 ppm of nitrogen increased as the concentration of dissolved oxygen was raised from 1.5 to 8.5 ppm. The effect of dissolved oxygen in increasing survival time was greater in the lower concentrations of unionized ammonia.	Downing and Merkens (1955)
Ammonia (unionized)	*Salmo gairdnerii* *Perca fluviatilis* *Rutilus rutilus* *Gobio gobio*	BSA	–	(O)	a c e o p	The resistance to rapidly lethal concentrations of unionized ammonia ranging from about 2.0 to 8.8 ppm nitrogen was determined in tensions of dissolved oxygen 53.4 and 96.7% of air saturation value at 15.2 C. Period of survival decreased with rise in concentration of unionized ammonia. The effect of oxygen tension on period of survival was greatest in the lowest concentrations of unionized ammonia.	Markens and Downing (1957)
Ammonia plus carbon dioxide	Rainbow trout	BSA	–	(O)	a e m n	The reduction of toxicity of ammonia solutions by the addition of carbon dioxide, was due to lowering the pH of the solution. 60-240 ppm CO_2 in solution was toxic within 12 hr. 30 ppm ammonia nitrogen was toxic, but up to 30 ppm CO_2 increased fish survival time.	Alabaster and Herbert (1954)
Ammonium acetate	*Gambusia affinis*	BSA	–	238 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Ammonium borofluoride	Sewage organisms	BOD	–	87.0 (O)	–	Various metal salts were studied in relation to how they affected the BOD of both raw and treated sewage as well as how they affected the processing of sewage in the treatment plant. BOD was used as the parameter to measure the effect of the chemical. The chemical concentration cited is the ppm required to reduce the BOD values by 50%. This chemical was tested in an unbuffered system.	Sheets (1957)
Ammonium carbonate	*Gambusia affinis*	BSA	--	238 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)

Ammonium chloride	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, possible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compares this work with earlier work, and lists an extensive bibliography. In 0.224N solution, fish survived 99 minutes.	Powers (1918)
Ammonium chloride	*Daphnia magna*	BSA	–	<134 (O)	a e	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Ammonium chloride	*Salmo gairdnerii*	BSA	–	(O) Tap water 1000 ppm – 27.3 min 1000 ppm – 52.5 min 50 ppm – >1000 min Distilled water 3000 ppm – 292 min 1000 ppm – 725 min 100 ppm > 4320 min	a c e f	Tap or distilled water used as diluent. Toxicity defined as the average time when the fish lost equilibrium when exposed to the test chemical (ppm ammonia).	Grindley (1946)
Ammonium chloride	*Daphnia magna*	BSA	–	91 (S)	a	Lake Erie water was used as diluent. Toxicity given as threshold concentration producing immobilization for exposure periods of 64 hr.	Anderson (1948)
Ammonium chloride	*Lepomis macrochirus*	BCFA	–	6.0 (T4A)	a c e f	Test water was composed of distilled water with CP grade chemicals and was aerated throughout the 96-hour exposure period. Toxicity was dependent upon the concentration of undissociated NH_4OH which is dependent upon pH. The initial pH was 9.0 and after four days it was 7.5.	Cairns and Scheier (1955)
Ammonium chloride	*Daphnia magna*	BSA	–	246.6 (O)	a c	The primary aim of this study was to determine the effects of lowered dissolved oxygen concentration upon an aquatic invertebrate when exposed to solutions of inorganic salts known to be present in various industrial effluents. Analysis of data conclusively shows the *D. magna* tested under lowered oxygen tension exhibited lower threshold values for the chemicals studied than when tested at atmospheric dissolved oxygen.	Fairchild (1955)
Ammonium chloride	*Gambusia affinis*	BSA	–	510 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Ammonium chloride	*Lepomis macrochirus*	BSA	–	7.7 (T4A)	a c d e i	A "control" was prepared by adding required chemicals to distilled water, and this was constantly aerated. Data reported are for larger fish, 14.24 cm in length. Data for smaller fish are also in the report.	Cairns and Scheier (1959)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Ammonium chloride (as N)	Rainbow trout	BSA	–	(O)	a c d	The 48-hour LD_{50} of ammonium chloride (as N) as interpolated from three graphs may be 30, 24, or 12 ppm. The effect of dissolved oxygen is also discussed.	Herbert (1961)
Ammonium chloride (as N)	*Salmo gairdnerii*	BSA	–	24.6 (T2A)	a c d f	A mathematical equation was derived to explain the combined toxicities of this salt and zinc sulfate.	Herbert and Shurben (1964)
Ammonium chloride	*Carassius carassius*	BSA	–	202 (T1A) 161 (T2A) 50 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
	Daphnia magna			139 (T4A)			
	Lepomis macrochirus			725 (T1-4A)			
	Lymnaea sp *(eggs)*			241 (T1A) 173 (T2A) 70 (T4A)			
Ammonium chromate	*Gambusia affinis*	BSA	–	270 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Ammonium dichromate	*Gambusia affinis*	BSA	–	212 (T2A)	a c d e g	Comment same as above.	Wallen, et al (1957)
Ammonium hydroxide	*Daphnia magna*	BSA	–	<8.75 (O)	a e	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Ammonium hydroxide	*Gasterosteus aculeatus*	BSA	–	(O)	c e	Tap water was used to make up the solutions. The fish avoided concentrations of 0.04 and 0.01N, but seemed attracted to concentrations of 0.001 and 0.0001N.	Jones (1948)
Ammonium hydroxide (as ammonia)	*Semotilus atromaculatus*	BSA	–	5 to 15 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
Ammonium hydroxide	*Gambusia affinis*	BSA	–	37 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Ammonium hydroxide	Fish	BSA	–	4.3×10^{-5} M (K)	a c	Avoidance behavior of test fish to toxic chemicals is given. Toxicity is given as the lowest lethal concentration (molar). Ratios of avoidance and lowest lethal concentration are presented and discussed.	Ishio (1965)

Ammonium hydroxide	*Daphnia magna*	BSA	–	60 (T1A) 32 (T2A) 20 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Ammonium nitrate	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, possible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compares this work with earlier work, and lists an extensive bibliography. In 0.213N solution, fish survived 78 minutes.	Powers (1918)
Ammonium salt	*Nitzschia linearis* *Physa heterostropha* *Lepomis macrochirus*	BSA	–	420 (T5A) 90.0 (T4A) 3.4 (T4A)	a c e	The purpose of this experiment was to determine whether there was a constant relationship between the responses of these organisms. From the data presented, there was no apparent relationship of this type. Therefore the authors advise that bioassays on at least 3 components of the food web be made in any situation.	Patrick, et al (1968)
Ammonium salts	*Salmo gairdnerii*	BSA	–	(O)	a e	This is a study of the effect of varying dissolved oxygen concentrations on the toxicity of selected chemicals. The toxicity of heavy metals, ammonia, and monohydric phenols increased as the dissolved oxygen in water was reduced. The most obvious reaction of fish to increase the volume of water passed over the gills, and this may increase the amount of poison reaching the surface of the gill epithelium. The concentration of the chemical in the water was not specified.	Lloyd (1961)
Ammonium sulfate	*Daphna magna*	BSA	–	<106 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Ammonium sulfate	*Daphnia magna*	BSA	–	288.5 (O)	a c	The primary aim of this study was to determine the effects of lowered dissolved oxygen concentration upon an aquatic invertebrate when exposed to solutions of inorganic salts known to be present in various industrial effluents. Analysis of data conclusively shows the *D. magna* tested under lowered oxygen tension exhibited lower threshold values for the chemicals studied than when tested at atmospheric dissolved oxygen.	Fairchild (1955)
Ammonium sulfate	*Salmo gairdnerii*	BSA	–	(O) Tap water 1000 ppm – 29.8 min Distilled water 3000 ppm – 318 min 1000 ppm – 847 min 100 ppm >5760 min	a c e f	Tap or distilled water used as diluent. Toxicity defined as the avg. time when the fish lost equilibrium when exposed to the test chemical (ppm ammonia).	Grindley (1946)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Ammonium sulfate	*Gambusia affinis*	BSA	–	1,400 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Ammonium sulfate	*Daphnia magna*	BSA	–	423 (T1A) 433 (T2A) 292 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Ammonium sulphate	*Biomorpholaria a. alexandrina* *Bulinus truncatus*	BSA	–	800 (K1A) 300 (K1A)	a	The degree of tolerance for vector snails of biharziasis chemicals is somewhat dependent upon temperature. The temperature at which (K1A) occurred was 28 C.	Gohar and El-Gindy (1961)
Ammonium sulfide	*Gambusia affinis*	BSA	–	248 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Ammonium sulfite	*Gambusia affinis*	BSA	–	240 (T2A)	a c d e g	Comment same as above.	Wallen, et al (1957)
Ammonium sulfite	*Daphnia magna*	BSA	–	299 (T1A) 273 (T2A) 203 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Ammonium thiocyanate	*Gambusia affinis*	BSA	–	420 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Amyl acetate	*Semotilus atromaculatus*	BSA	–	50 to 120 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
N-amyl-acetate	*Gambusia affinis*	BSA	–	65 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
n-amyl alcohol	*Semotilus atromaculatus*	BSA	–	350 to 500 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
t-amyl alcohol	*Semotilus atromaculatus*	BSA	–	1,300 to 2,000 (CR)	a e	Comment same as above.	Gillette, et al (1952)
Aniline	*Daphnia magna*	BSA	–	279 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)

Aniline	*Microcystis aeruginosa*	L	–	50 (K)	a	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
Aniline hydrochloride	*Daphnia magna*	BSA	–	5.5 (K2)	a	An attempt was made to correlate the biological action with the chemical reactivity of selected chemical substances. Results indicated a considerable correlation between the aquarium fish toxicity and antiautocatalytic potency of the chemicals in marked contrast to their toxicity on systemic administration.	Sollman (1949)
Antimony potassium tartrate	*Pimephales promelas*	BSA	–	12 (T4A) H 20 (T4A) S	a c d f	Both hard (H) and soft (S) water were used.	Tarzwell and Henderson (1960)
Antimony trichloride	*Daphnia magna*	BSA	–	37 (S)	a	Lake Erie water was used as diluent. Toxicity given as threshold concentration producing immobilization for exposure periods of 64 hr.	Anderson (1948)
Antimony trichloride	*Pimephales promelas*	BSA	–	17 (T4A) H 9 (T4A) S	a c d f	Both hard (H) and soft (S) water were used.	Tarzwell and Henderson (1960)
Antimony trioxide	*Pimephales promelas*	BSA	–	>80 (T4A) H >80 (T4A) S	a c d f	Comment same as above.	Tarzwell and Henderson (1960)
Arsenite	*Lepomis macrochirus* (eggs) *L. cyanellus* (eggs) *Micropterus dolomieui* (eggs)	L	–	15/7 (O), 8 (NTE) 15 (NTE), 8 (NTE) 15/6 (O), 8 (NTE)	–	Fertilized fish eggs of indicated species were placed in 1 liter of test solution and allowed to hatch. Toxicity data are presented as concentration in ppm/number of days survival. Maximum length of test was 8 days. No food was added. Small bluegill were tested to find the highest concentration of chemical which did not cause death in 12 days (O).	Hiltibran (1967)
Barium carbonate	*Gambusia affinis*	BSA	–	10,000 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Barium chloride	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, possible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compares this work with earlier work, and lists an extensive bibliography. In 0.172N solution, fish survived 169 minutes.	Powers (1918)
Barium chloride	*Daphnia magna*	BSA	–	<83 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Barium chloride	*Daphnia magna*	BSA	–	29 (O)	a	Lake Erie water was used as diluent. Toxicity given as threshold concentration producing immobilization for exposure periods of 64 hr.	Anderson (1948)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Barium chloride	*Gambusia affinis*	BSA	–	3,200 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Barium chloride	*Rana* sp (eggs)	BSA	–	24,430 K	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Barium nitrate	*Gasterosteus aculeatus*	BSA	–	400 (K10)	–	Solutions were made up in tap water. 3.0 to 5.0 cm stickleback fish were used as experimental animals. This paper points out that there is a marked relationship between the toxicity of the metals and their solution pressures. Those with low solution pressures were the most toxic.	Jones (1939)
Benzanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	(O)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule. At 10 ppm, there was no toxicity to goldfish or trout.	Walker, et al (1966)
Benzene	*Gambusia affinis*	BSA	–	395 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Benzene	*Pimephales promelas* *Lepomis macrochirus* *Carassius auratus* *Lebistes reticulatus*	BSA	–	31 (T4A) 22 (T4A) 32 (T4A)	a c d e f	Most fish survived at test concentrations of about one half, or slightly more, of the TL_m value. No attempt was made to estimate 100 percent survival.	Pickering and Henderson (1966)
Benzidine	*Microcystis aeruginosa*	L	–	50 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
Benzoic acid	*Carassius auratus*	BSA	–	0.165 (K)	a	Goldfish weighed between 2 and 4 g. Temperature was maintained at 27.0 ± 0.2 C.	Gersdorff (1943)
Benzoic acid	*Daphnia magna*	BSA	–	146 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes determined by the use of *D. magna*. Centrifuged Lake Erie water was used as diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)

Benzoic acid	*Gambusia affinis*	BSA	–	225 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Benzonitrile	*Pimephales promelas*	BSA	–	(S) 135.0 (T4A) (H) 78.0 (T4A)	c d e f	(H) Value in softwater (S) Value in softwater	Henderson, et al (1960)
	Lepomis macrochirus			(S) 78.0 (T4A)		The chemical did not change the flavor of the cooked bluegill.	
	Lebistes reticulatus			(S) 400.0 (T4A)			
2-benzoyl-1,3-dichloropropane	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – T (7), PT (21) Ma – T So – PT (7) Cv – T Gp – T Np – T	Palmer and Maloney (1955)
3-benzyl-5,5-dimethyl-2-imidazolinethione	*Microcystis aeruginosa*	L	–	10.0 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
bis-benzyl ethylene diamine diacetate	*Semotilus atromaculatus*	BSA	–	5 to 20 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
Beryllium chloride	*Pimephales promelas*	BSA	–	(H) 15 (T4A) (S) 0.15 (T4A)	a c d f	Both hard (H) and soft (S) water were used.	Tarzwell and Henderson (1960)
Beryllium nitrate	*Pimephales promelas*	BSA	–	(H) 20 (T4A) (S) 0.15 (T4A)	a c d f	Comment same as above.	Tarzwell and Henderson (1960)
Beryllium sulfate	*Pimephales promelas*	BSA	–	(H) 11 (T4A) (S) 0.2 (T4A)	a c d f	Comment same as above.	Tarzwell and Henderson (1960)
	Lepomis macrochirus			(H) 12 (T4A) (S) 1.3 (T4A)			
Beryllium sulfate plus sodium tartrate	Goldfish Minnow Snails Water plants	BSA	–	(O)	c e	After 10 days of incremental additions of the chemicals to the aquarium, the final concentrations were: beryllium – 28.5 ppm; sulfate – 302 ppm; sodium tartrate – 664 ppm. No toxic effect to the animals or plants was observed after 10 days of exposure.	Pomelee (1953)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Boric acid	Sewage organisms	BOD	–	480 (O)	–	Various metal salts were studied in relation to how they affected the BOD of both raw and treated sewage as well as how they affected the processing of sewage in the treatment plant. BOD was used as the parameter to measure the effect of the chemical. The chemical concentration cited is the ppm required to reduce the BOD values by 50%. This chemical was tested in an unbuffered system.	Sheets (1957)
Boric acid	*Gambusia affinis*	BSA	–	10,500 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Boric acid	Sewage organisms	BOD	–	>1000 (TC_{50})	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Bromine	*Chlorella pyrenoidosa*	BSA	–	0.18 (O) 0.42 (O)		At 0.18 ppm, 2,100 cells/mm^3 remained at the end of 4 days as compared with a count of 2,383 cells/mm^3 in control. At 0.42 ppm, 270 cells/mm^3 remained at the end of 4 days as compared with 2,383 cells/mm^3 in controls. Bromine showed no inhibitory effect in the first 48 hr. Experiments were carried out in seven-liter containers of tap water. By maintaining a constant level of 0.2 ppm of bromine, it would be possible to kill algae in water.	Kott, et al (1966)
3'-bromo-3, 5-dinitro-benzanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	(O)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule. At 1.0 ppm, this chemical was toxic to 4 out of 10 trout; but at the concentrations (.1, 1.0, 10.0) there was no toxicity to goldfish.	Walker, et al (1966)
4'-bromo-3, 5-dinitrobenz-anilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	(O) (O)	a	Comment same as above except that at 10 ppm the chemical was not toxic to trout or goldfish.	Walker, et al (1966)
4'-bromo-2-nitrobenz-anilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	10 (K2) (O)	a	Comment same as above except that at 10.0 ppm, this chemical was toxic to 2 out of 10 goldfish in 48 hours.	Walker, et al (1966)

2'-bromo-3-nitrosalicylanilide	Sea lamprey (larva)	BSA	–	1.0 (K)	See Applegate, et al (1957-1958)	This paper deals with the comparative toxicity of halonitrosalicylanilides to sea lamprey and fingerling rainbow trout as a function of substituent loci.	Starkey and Howell (1966)
	Salmo gairdneri (fingerling)			1.0 (K)			
3'-bromo-3-nitrosalicylanilide	Sea lamprey (larva)	BSA	–	0.3 (K)	Ditto	Comment same as above.	Starkey and Howell (1966)
	Salmo gairdneri (fingerling)			(O)		1.0 ppm killed 25%.	
4'-bromo-3-nitrosalicylaniline	Sea lamprey (larva)	BSA	–	0.3 (K)	"	Comment same as above.	Starkey and Howell (1966)
	Salmo gairdneri (fingerling)			(O)		1.0 ppm killed 25%.	
4'-bromo-5-nitrosalicylanilide	Sea lamprey (larva)	BSA	–	0.5 (K)	"	Comment same as above.	Starkey and Howell (1966)
	Salmo gairdneri (fingerling)			(O)		1.5 ppm killed 25%.	
3-bromo-4-nitrophenol (free phenol)	*Petromyzon marinus*	BSA	–	5 (K 100%)	a	Mortality occurred in approximately 24 hr. This was a study on controlling sea lamprey larvae.	Ball (1966)
	Lepomis macrochirus	BSA	–	15 (K 10%)	a		
	Salmo gairdnerii	BSA	–	11 (K 10%)	a		
2-bromo-4-nitrophenol (free phenol)	*Petromyzon marinus*	BSA	–	5 (K 100%)	a	Comment same as above.	Ball (1966)
	Salmo gairdnerii	BSA	–	13 (K 10%)	a		
	S. trutta	BSA	–	11 (K 10%)	a		
2-bromo-4-nitrophenol (Na salt)	*Petromyzon marinus*	BSA	–	7 (K 100%)	a	Comment same as above.	Ball (1966)
	Salmo gairdnerii	BSA	–	15 (K 10%)	a		
2-bromo-4-nitrophenol	*Petromyzon marinus* (larvae)	BSA	–	10 (K14)	a	Additional data are presented.	Piavis (1962)
3-bromo-4-nitrophenol	*Petromyzon marinus* (embryos and prolarvae) (larvae)	BSA	–	10 (K5-18) 10 (K2-4 hr)	a	Comment same as above.	Piavis (1962)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
4'-bromo-3-nitro-o-salicylotoluidide	*Salmo gairdnerii*	BSA	–	1.0 (K 3 hr)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule.	Walker, et al (1966)
	Carassius auratus			1.0 (K2) 10.0 (K 3 hr)			
3'-bromo-3-nitrosalicylanilide	*Salmo gairdnerii*	BSA	–	1.0 (K 3 hr)	a	Comment same as above.	Walker, et al (1966)
	Carassius auratus			1.0 (K2) 10.0 (K 3 hr)			
4'-bromo-3-nitrosalicylanilide	*Salmo gairdnerii*	BSA	–	1.0 (K 3 hr)	a	Comment same as above.	Walker, et al (1966)
	Carassius auratus			1.0 (K2) 10.0 (K 3 hr)			
2-butanone	*Gambusia affinis*	BSA	–	5,600 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
n-butyl alcohol	*Semotilus atromaculatus*	BSA	–	1,000 to 1,400 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
t-butyl alcohol	*Semotilus atromaculatus*	BSAq	–	3,000 to 6,000 (CR)	a e	Comment same as above.	Gillette, et al (1952)
Butyric acid	*Daphnia magna*	BSA	–	61 (T2A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
	Lepomis macrochirus			200 (T1A)			
Cadmium	*Lebistes reticulatus*	BSA	–	1.0 (K)	a c e	It is assumed in this experiment that the cations considered are toxic because they combine with an essential sulfhydryl group attached to a key enzyme. This treatment indicates that the metals which form the most insoluble sulfides are the most toxic. The log of the concentration of the metal ion is plotted against the log of the solubility product constant of the metal sulfide – a treatment that does not lend itself to tabulation. The cation toxicity cited is only an approximate concentration interpolated from a graph. Time of death was not specified.	Shaw and Grushkin (1967)
	Bufo valliceps (tadpoles)			1.0 (K)			
	Daphnia magna			0.01 (K)			

Cadmium	*Salmo gairdnerii*	BCFA	–	(O)	–	A small, cone-shaped, cadmium-plated metal screen was used to cover a 2-inch pipe outlet. Recirculating 2,500 gallons of water through the screen at the rate of 50 gallons per minute killed 16-per-pound rainbow trout in 24 hours. Rainbow trout placed in a 15-gallon tub of water, with recirculation through the cadmium screen were dead within 10 hours.	Roberts (1963)
Cadmium	*Lepomis macrochirus* *Ictalurus nebulosus*	BSCFCH	–	0.1-100.0	a c d e f	Fish were exposed to 8, 16, and 20 ppm of cadmium for varying periods of time (up to 90 days). In living fish the accumulation of cadmium never exceeded 130 μg/g of gill tissue, based on dry weight. In fish that died of poisoning, the accumulation of cadmium was a maximum of 634 μg/g of gill tissue. The authors state that high cadmium content (3-400 μg/g) in the liver of a fish would indicate a past history of exposure.	Mount and Stephan (1967)
Cadmium	*Salmo gairdnerii*	BCFA	–	0.008- 0.01 (T7A) 30 mg (T1A)	a b f	The data show that even at high concentrations, the toxic effect to the fish was very slow. Experiments were conducted in hard water.	Ball (1967)
Cadmium	*Salmo gairdnerii*	BCFA	–	30 (T1A)	a b f	A 7-day TL_m may be between 0.008 and 0.01 ppm. Despite this high toxicity, the response of the fish to the poison was initially very slow, even at high concentrations.	Velsen and Alderdice (1967)
Cadmium chloride	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, possible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compares this work with earlier work, and lists an extensive bibliography. In a 0.157N solution, fish survived 70 minutes; in a solution of 0.000000037N, they survived 442 minutes.	Powers (1918)
Cadmium chloride	*Daphnia magna*	BSA	–	<0.0026 (S)	a	Lake Erie water was used as diluent. Toxicity given as threshold concentration producing immobilization for exposure periods of 64 hr.	Anderson (1948)
Cadmium chloride	*Pimephales promelas*	BSA	–	5 (T4A) H 0.9 (T4A) S	a c d f	Both hard (H) and soft (S) water were used.	Tarzwell and Henderson (1960)
Cadmium chloride	*Limnaea palustris* (eggs)	BSA	–	6×10^{-6} m (K1)	a c	Toxicity is given in molar concentrations for maximum direct mortality (kill) in 4 hours.	Morrill (1963)
Cadmium chloride	*Pimephales promelas* *Lepomis macrochirus* *Lebistes reticulatus* Green sunfish	BSA	–	(S) 1.05 (T4A) (H) 72.6 (T4A) (S) 1.94 (T4A) (S) 1.27 (T4A) (S) 2.84 (T4A) (H) 66.0 (T4A)	c d e f	(S) Soft water (H) Hard water Values are expressed as mg/l of metal.	Pickering and Henderson (1965)
Cadmium cyanide complex	*Lepomis macrochirus* (juveniles)	BSA	–	0.64 (O)	a c d f p	For the concentration given, the median resistance time was 134 minutes.	Doudoroff, et al (1966)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Cadmium cyanide complex, sodium cyanide (439 ppm CN), and cadmium sulfate (528 ppm Cd)	*Pimephales promelas*	BSA	–	0.17 (T4A)	a c	Synthetic soft water was used. Toxicity data given as number of test fish surviving after exposure at 24, 48, and 96 hr. TL_m values were estimated by straight-line graphical interpolation and given in ppm CN^-.	Doudoroff, et al (1956)
Cadmium nitrate	*Gasterosteus aculeatus*	BSA	–	0.2 (K10)	–	Solutions were made up in tap water. 3.0 to 5.0 cm stickleback fish were used as experimental animals. This paper points out that there is a marked relationship between the toxicity of the metals and their solution pressures. Those with low solution pressures were the most toxic.	Jones (1939)
Cadmium sulfate	Sewage organisms	BOD	–	142 (TC_{50})	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Caffeine	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, possible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compares this work with earlier work, and lists an extensive bibliography. In a concentration of 0.285 g/liter, fish survived 94 minutes.	Powers (1918)
Calcium carbonate	*Gambusia affinis*	BSA	–	56,000 (T2A)	a c d e g	The effect of turbidity on the toxicity on the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Calcium chloride	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, possible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compares this work with earlier work, and lists an extensive bibliography. In 0.249N solution, fish survived 174 minutes.	Powers (1918)
Calcium chloride	*Daphnia magna*	BSA	–	1332 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Calcium chloride	*Daphnia magna*	BSA	–	920 (S)	a	Lake Erie water was used as diluent. Toxicity given as threshold concentration producing immobilization for exposure periods of 64 hr.	Anderson (1948)

Calcium chloride	*Lepomis macrochirus*	BSA	–	10,650 (T4A)	a d e f	This paper reports the LD_{50} in 96 hours for 8 common inorganic salts. A synthetic dilution water of controlled hardness was prepared for use in the experiments. Among other variables, specific conductivity, as mhos at 20 C, was measured. If this salt is toxic to fish, this experiment did not demonstrate it.	Trama (1954)
Calcium chloride	*Lepomis macrochirus*	BCFA	–	9,500 (T4A) small 11,300 (T4f) large	a c e f	Test water was composed of distilled water with CP grade chemicals and was aerated throughout the 96-hour exposure period.	Cairns and Scheier (1955)
Calcium chloride	*Daphnia magna*	BSA	–	3,972 (O)	a c	The primary aim of this study was to determine the effects of lowered dissolved oxygen concentration upon an aquatic invertebrate when exposed to solutions of inorganic salts known to be present in various industrial effluents. Analysis of data conclusively shows the *D. magna* tested under lowered oxygen tension exhibited lower threshold values for the chemicals studied than when tested at atmospheric dissolved oxygen.	Fairchild (1955)
Calcium chloride	*Gambusia affinis*	BSA	–	13,400 (T2A)	a c d e g	The effect of turbidity on the toxicity on the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Calcium chloride	*Lepomis macrochirus*	BSA	–	11,300 (T4A)	a c d e i	A "control" was prepared by adding required chemicals to distilled water, and this was constantly aerated. Data reported are for larger fish, app 14.24 cm in length. Data for smaller fish are also in the report.	Cairns and Scheier (1959)
Calcium chloride	*Daphnia magna* *Lepomis macrochirus* *Lymnaea* sp *(eggs)*	BSA	–	3,526 (T1A) 3,005 (T2A) 8,350 (T1A) 4,485 (T1A) 3,094 (T2A) 2,373 (T3A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Calcium chloride	*Nitzschia linearis* *Lepomis macrochirus*	BSA	–	3,130 (T5A) 10,650 (T4A)	a c e	The purpose of this experiment was to determine whether there was a constant relationship between the responses of these organisms. From the data presented, there was no apparent relationship of this type. Therefore the authors advise that bioassays on at least 3 components of the food web be made in any situation.	Patrick, et al (1968)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Calcium hydroxide	*Micropterus salmoides* *Lepomis machrochirus* *Goldfish*	BSA	–	100 (O) 100 (O) 100 (O)	a c f p i	The disposal of cannery wastes frequently involves the use of chemicals for treatment purposes. Ferrous sulphate, alum, and lime are used in chemical coagulation; sodium carbonate for acidity control in biological filters; and sodium nitrate in lagoons for odor control. Lye (sodium hydroxide) peeling of certain fruits and vegetables is not uncommon. These chemicals, in whole or part, are discharged in most cases to a stream. The concentration listed permitted large mouth bass to survive 3 to 5 hours, bluegills to survive 2 to 4.5 hours, and goldfish to survive 3 to 3.5 hours.	Sanborn (1945)
Calcium hydroxide	*Gambusia affinis*	BSA	–	220 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Calcium hydroxide	*Biomorpholaria alexandrina* *Bulinus truncatus* *Lymnaea caillaudi*	BSA	–	300 (K1) 300 (K1) 300 (K1)	a	The degree of tolerance for vector snails of bilharziasis to various chemicals is somewhat dependent upon temperature. The temperature at which (K1) occurred was 28 C.	Gohar and El-Gindy (1961)
Calcium hypochlorite	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – T (3) Ma – T (3) So – T (3), PT (7) Cv – T (3) Gp – T (3) Np – T (3)	Palmer and Maloney (1955)
Calcium hypochlorite	Blue-green algae *Cylindrospermum* *Anabaena* *Anacystis* *Calothrix* *Nostoc* *Oscillatoria* *Plectonema* Green algae *Ankistrodesmus* *Chlorella* *Closterium* *Oocystis* *Scenedesmus* *Stigeoclonium* *Zygnema*	L	–	2.0 (O)	–	$Ca(OCl)_2$ was toxic or partially toxic to all of the algae species at the indicated concentration for 28 days.	Kemp, et al (1966)

	Green flagellate and yellow algae *Chlamydomonas* *Pandorina* *Tribonema* *Gomphonema* *Navicula* *Nitzchia*						
Calcium nitrate	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, possible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compares this work with earlier work, and lists an extensive bibliography. In 0.192N solution, fish survived 186 minutes.	Powers (1918)
Calcium nitrate	*Gasterosteus aculeatus*	BSA	–	800 (K10)	–	Solutions were made up in tap water. 3.0 to 5.0 cm stickleback fish were used as experimental animals. This paper points out that there is a marked relationship between the toxicity of the metals and their solution pressures. Those with low solution pressures were the most toxic.	Jones (1939)
Calcium nitrate	*Gasterosteus aculeatus* *Phoxinus phoxinus*	BSA	–	(O)	c e	Tap water was used to make up the solutions. The fish were indifferent to dilute solutions – 0.001 N, but they were attracted to a solution of 0.04 N. At 0.0004 N they swam out of the solution to a water zone. At 0.00002 N they still showed an avoidance reaction.	Jones (1948)
Calcium nitrate	*Lepomis macrochirus*	BSA	–	10,000 (T4A)	a d e f	This paper reports the LD_{50} in 96 hours for 8 common inorganic salts. A synthetic dilution water of controlled hardness was prepared for use in the experiments. Among other variables, specific conductivity, as mhos at 20 C, was measured. If this salt is toxic to fish, this experiment did not demonstrate it.	Trama (1954)
Calcium sulfate	*Lepomis macrochirus*	BSA	–	2,980 (NTE)	a d e f	Comment same as above.	Trama (1954)
Calcium sulfate	*Gambusia affinis*	BSA	–	56,000 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Calcium sulphate	*Biomorpholaria a. alexandrina*	BSA	–	(O)	a	The degree of tolerance for vector snails of biharziasis chemicals is somewhat dependent upon temperature. The tolerance for *Bulinus, Lymnaea*, and *Biomphalaria* was up to saturation.	Gohar and El-Gindy (1961)
	Bulinus truncatus			(O)			
	Lymnaea caillaudi			(O)			
Calcium sulfate	Rainbow trout	BSCHA	–	(O)	a c e	This report concludes that fish in contact with a system containing 10,000 ppm of gypsum could survive for a day, or could survive in a system containing 6.820 ppm for three weeks. Also, that concentrations of 3.163 ppm or less should be safe for four weeks or much longer periods.	Herbert and Wakeford (1962)

CHEMICALS AND MIXTURES OF CHEMICALS

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Calcium suiphate	*Nitzschia linearis* *Lepomis macrochirus*	BSA	–	3,200 (T5A) 2,980 (T4A)	a c e	The purpose of this experiment was to determine whether there was a constant relationship between the responses of these organisms. From the data presented, there was no apparent relationship of this type. Therefore the authors advise that bioassays on at least 3 components of the food web be made in any situation.	Patrick, et al (1968)
Capric acid	*Lepomis macrochirus*	BSA	–	(O)	–	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water. Chemical is only slightly soluble in water. No toxicity data were obtained.	Dowden and Bennett (1965)
Caproic acid	*Lepomis macrochirus*	BSA	–	150 - 200 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Caprylic acid	*Lepomis macrochirus*	BSA	–	(O)	–	Comment same as above except that compound was very insoluble in water. No toxicity data were obtained.	Dowden and Bennett (1965)
Carbon chloroform extract (CCE)	Trout	BSA	–	36 (T1A) 32 (T2A) 28 (T4A) 24 (T5A)	a c d e f i m	The objects of this investigation were the recovery of organic micropollutants from subsurface and surface Missouri waters, characterization and identification of these substances, and evaluation of their toxic effects, both acute and long-term, in order to develop methods for their destruction or removal.	Smith and Grigoropoulos (1968)
	Golden Shiner			59 (T1A) 52 (T2A) 39 (T4A) 33 (T5A)			
	Sunfish			56 (T1A) 49 (T2A) 45 (T4A) 39 (T5A)			
Carbon chloroform extract (CCE)/ carbon alcohol extract (CAE) 1/1.48	Trout	BSA	–	130 (T1A) 125 (T2A) 95 (T4A) 82 (T5A)	a c d e f i m	Comment same as above.	Smith and Grigoropoulos (1968)
	Red Shiner			No effect up to 305 (T5A)			
	Sunfish			166 (T1A) 144 (T2A) 115 (T4A) 103 (T5A)			
Carbon chloroform extract (CCE)/ carbon alcohol extract (CAE) 1/1.56	Trout	BSA	–	138 (T1A) 130 (T2A) 96 (T4A) 92 (T5A)	a c d e f i m	Comment same as above.	Smith and Grigoropoulos (1968)
	Red Shiner			No effect up to 240 (T5A)			

Carbon dioxide	Trout	BSA	–	(O)	a c	No quantitative data are reported. 30 ppm of nitrogen was added as ammonium chloride. Carbon dioxide in concentrations up to 30 ppm reduced the toxicity of the ammonia by lowering the pH of the water. Concentrations of 60 ppm of CO_2 were toxic but not lethal when the concentration of dissolved oxygen was low. A concentration of 240 ppm of CO_2 was lethal to trout in little more than one hour.	Herbert (1955)
Carbon dioxide plus ammonia	Rainbow trout	BSA	–	(O)	a e m n	The reduction of toxicity of ammonia solutions by the addition of carbon dioxide was due to lowering the pH of the solution. 60-240 ppm CO_2 in solution was toxic within 12 hr. 30 ppm ammonia nitrogen was toxic, but up to 30 ppm CO_2 increased fish survival time.	Alabaster and Herbert (1954)
Carbon disulfide	*Gambusia affinis*	BSA	–	135 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Carbonic acid	Fish	BSA	–	6.5 x 10^{-4} M (K)	a c	Avoidance behavior of test fish to toxic chemicals is given. Toxicity is given as the lowest lethal concentration (molar). Ratios of avoidance and lowest lethal concentration are presented and discussed.	Ishio (1965)
Cetyldimethyl ammonium bromide plus alkylate ether alcohol	*Cylindrospermum licheniforme (Cl)* *Gleocapsa sp (G)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – NT G – NT So – NT Cv – NT Gp – NT Np – NT	Palmer and Maloney (1955)
Cetylpyridinum-bromide	*Microcystis aeruginosa*	L	–	2.0 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
Cetyltrimethyl-ammonium bromide	*Microcystis aeruginosa*	L	–	2.0 (K)	a, etc	Comment same as above.	Fitzgerald, et al (1952)
Chlorauric acid	*Gasterosteus aculeatus*	BSA	–	0.4 (K10)	–	Solutions were made up in tap water. 3.0 to 5.0 cm stickleback fish were used as experimental animals. This paper points out that there is a marked relationship between the toxicity of the metals and their solution pressures. Those with low solution pressures were the most toxic.	Jones (1939)
Chloride plus fluoride	Rainbow trout	BSA	–	(O)	a i	When trout were exposed to 30 ppm Cl^- for 48 hours and then challenged with fluoride, the LC_{50} of the fluoride was 6 ppm. No exposure to Cl^- resulted in an LC_{50} of 22 ppm Fl^-.	Neuhold and Sigler (1962)

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Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Chlorinated benzene	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – T Ma – T So – T (3), PT (21) Cv – T Gp – T Np – T	Palmer and Maloney (1955)
Chlorinated camphene (60 percent)	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Comment same as above except that: Cl – PT Ma – T (14), PT (21) So – PT (14), NT Cv – PT Gp – T (3) Np – PT (7)	Palmer and Maloney (1955)
Chlorine (from mono- and di-chloramines)	*Salmo gairdnerii*	BCFA	–	0.08 (T7A)	a c e	The purpose of this paper was to investigate the toxicity of chlorine to the rainbow trout in solutions containing ammonia. The toxicity of residual chlorine was dependent upon the relative proportions of free chlorine and chloramines.	Merkens (1958)
Chlorine	*Nais* spp	BSA	–	1.0 (K)	a f	All tests were conducted in hard water. At 1.0 ppm of chlorine, 95% of the worms were killed after 35 minutes. There was considerable variation in chlorine tolerance below 2 ppm and contact times from 1-3 hours may be necessary for a complete kill.	Learner and Edwards (1963)
Chlorine	*Chlorella pyrenoidosa*	BSA	–	0.18 (O) 0.42 (O)	a c i	At 0.18 ppm, 1,900 cells/mm^3 remained at the end of 4 days as compared with a count of 2,383 cells/mm^3 in controls. At 0.42 ppm, 500 cells/mm^3 remained at the end of 4 days as compared with a count of 2,383 cells/mm^3 in controls. Chlorine showed an inhibitory effect in 48 hr. Experiments were carried out in seven-liter containers of tap water. By using 0.2 ppm of free chlorine, one might expect not to reduce the numbers of algae appreciably but to keep the population constant.	Kott, et al (1966)

3'-chloro-5-acetamidosalicylanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	10.0 (K 3 hr) 10.0 (K2)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule.	Walker, et al (1966)
p-chlorobenzanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	(O) (O)	a	Comment same as above except that at 10 ppm this chemical was not toxic to trout or goldfish.	Walker, et al (1966)
Chlorobenzene	*Pimephales promelas* *Lepomis macrochirus* *Carassius auratus* *Lebistes reticulatus*	BSA	–	29 (T4A) 20 (T4A) 45 (T4A) 44 (T4A)	a c d	Most fish survived at test concentrations of about one half, or slightly more, of the TL_m value. No attempt was made to estimate 100 percent survival.	Pickering and Henderson (1966)
Chlorobenzilate	*Daphnia magna*	BSA	–	1.4 (O)	a	.The indicated concentration immobilized *Daphnia* in 50 hours.	Anderson (1960)
Chlorobenzilate	*Simocephalus serrulatus* *Daphnia pulex*	BSA	–	0.550 (SB) 0.870 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 48 hr. Data cited are for 60 F, but assays were performed at varied temperatures. "Water Chemistry" (Unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
4'-chloro-5-bromo-3-nitrosalicylanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	0.1 (K2) 1.0 (K 3 hr) 1.0 (K2) 10.0 (K 3 hr)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule.	Walker, et al (1966)
4'-chloro-2,5-dihydroxy diphenyl sulphone	*Daphnia magna*	BSA	–	28.9 (K2A)	a	An attempt was made to correlate the biological action with the chemical reactivity of selected chemical substances. Results indicated a considerable correlation between the aquarium fish toxicity and antiautocatalytic potency of the chemicals in marked contrast to their toxicity on systemic administration.	Sollman (1949)
4 chlorohexyl-2,6-dinitrophenol, tech.	*Lymnaeid* snails	BSA	–	(O)		Each test container, 500-ml beaker, was filled with ditch water. 100% mortality occurred in concentrations of 1:400,000 and greater.	Batte, et al (1951)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
2'-chloro-5'-methyl-3-nitrosalicylanilide	Sea lamprey (larva)	BSA	–	0.7 (LD_{100})	See Applegate, et al (1957-1958)	This paper deals with the comparative toxicity of halonitrosalicylanilides to sea lamprey and fingerling rainbow trout as a function of substituent loci.	Starkey and Howell (1966)
	Salmo gairdneri (fingerling)			1.0 (LD_{25})			
2'-chloro-3-nitrosalicylanilide	Sea lamprey (larva)	BSA	–	3.0 (K)	Ditto	Comment same as above.	Starkey and Howell (1966)
	Salmo gairdneri (fingerling)			(O)		70 ppm killed 25%.	
2'-chloro-5-nitrosalicylanilide	Sea lamprey (larva)	BSA	–	0.9 (K)	"	Comment same as above.	Starkey and Howell (1966)
	Salmo gairdneri (fingerling)			(O)		3.0 ppm killed 25%.	
3'-chloro-3-nitrosalicylanilide	Sea lamprey (larva)	BSA	–	0.3 (K)	"	Comment same as above.	Starkey and Howell (1966)
	Salmo gairdneri (fingerling)			(O)		0.9 ppm killed 25%.	
3'-chloro-5-nitrosalicylanilide	Sea lamprey (larva)	BSA	–	15.0 (K)	"	Comment same as above.	Starkey and Howell (1966)
	Salmo gairdneri (fingerling)			(O)		15.0 ppm killed 25%.	
4'-chloro-3-nitrosalicylanilide	Sea lamprey (larva)	BSA	–	0.3 (K)	"	Comment same as above.	Starkey and Howell (1966)
	Salmo gairdneri (fingerling)			(O)		0.7 ppm killed 25%.	
4'-chloro-5-nitrosalicylanilide	Sea lamprey (larva)	BSA	–	0.5 (K)	"	Comment same as above.	Starkey and Howell (1966)
	Salmo gairdneri (fingerling)			(O)		1.0 ppm killed 25%.	
m-chlorophenol	*Carassius auratus*	BSA	–	70.5 to 219 (K 8 hr) 61.7 (O) 20.6 (O)	a	Temperature in test containers was maintained at 27 ± 0.2 C. Goldfish tested weighed between 2 and 4 g. m-chlorophenol, 61.7 mg per liter, killed 93% of the fish in 8 hr; 20.6 mg per liter killed 62% in 8 hr.	Gersdorff and Smith (1940)
o-chlorophenol	*Carassius auratus*	BSA	–	142 to 311 (K 8 hr) 104 (O) 82.8 (O) 10.0 (O)	a	Comment same as above except that o-chlorophenol, 104 mg per liter, killed 83% of the fish in 8 hr; 82.8 mg per liter killed 64% in 8 hr; and 10.0 mg per liter killed 20% in 8 hr.	Gersdorff and Smith (1940)

p-chlorophenol	*Carassius auratus*	BSA	–	54.3 to 190 (K 8 hr) 47.5 (O) 12.7 (O) 6.3 (O)	a	Comment same as above except that p-chlorophenol, 47.5 mg per liter, killed 85% of the fish in 8 hr; 12.7 mg per liter killed 75% in 8 hr; and 6.3 mg per liter killed 54% in 8 hr.	Gersdorff and Smith (1940)
4'-chloro-2', 5'-dimethoxy-3-nitrosalicylanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	1.0 (K 3 hr) 1.0 (K2) 10.0 (K 3 hr)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule.	Walker, et al (1966)
5'-chloro-3, 5-dinitro-2-benzanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	(O) (O)	a	Comment same as above except that at 10 ppm the chemical was not toxic to trout. At 1.0 ppm, 1 out of 10 goldfish died. This may not be valid since at 10 ppm, no fish were killed.	Walker, et al (1966)
2'-chloro-3, 5-dinitro-benzanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	(O) (O)	a	Comment same as above except that at 10 ppm this chemical was not toxic to trout or goldfish.	Walker, et al (1966)
3'-chloro-3, 5-dinitro-benzanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	(O) (O)	a	Comment same as above except that at 10.0 ppm the chemical was toxic to 7 out of 10 trout in 48 hours. No goldfish were killed at this and lower concentrations.	Walker, et al (1966)
3'-chloro-3,5-dinitro-o-benzotoluidide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	10.0 (K 3 hr) (O)	a	Comment same as above except that at 10 ppm the chemical was not toxic to goldfish. Precipitation occurred at 10 ppm.	Walker, et al (1966)
3'-chloro-3, 5-dinitro-p-benzotoluidide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	(O) (O)	a	Comment same as above except that at 10.0 ppm the chemical was toxic to 2 out of 10 trout in 48 hours. The chemical was not toxic to goldfish at 10.0 ppm.	Walker, et al (1966)
5'-chloro-3, 5-dinitro-3-benzotoluidide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	10.0 (K 3 hr) (K 3 min.) (O)	a	Comments same as above except that at 10 ppm the chemical was not toxic to goldfish.	Walker, et al (1966)
2'-chloro-3', 4'-dinitro-salicylanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	1.0 (K 3 hr) 1.0 K (K2) 10.0 (K 3 hr)	a	Comment same as above except data cited.	Walker, et al (1966)
Chloroform	*Pygosteus pungitius*	BCF	–	(O)	a	A 1/2000 solution anaesthetized or killed very rapidly. 1/5000 and 1/10000 induced an avoidance reaction in the fish.	Jones (1947)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Chloroform	Sewage organisms	BOD	–	(NTE)	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
3'-chloro-3-hydroxy-benzanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	10.0 (K2) (O)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule. At 10.0 ppm, the chemical was toxic to 7 out of 10 goldfish at 48 hours.	Walker, et al (1966)
4'-chloro-3-hydroxybenz-anilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	10.0 (K2) (O)	a	Comment same as above except that at 10.0 ppm the chemical was toxic to 2 out of 10 goldfish in 48 hours.	Walker, et al (1966)
2'-chloro-2-nitrobenz-anilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	(O) (O)	a	Comment same as above except that this chemical was not toxic to trout or goldfish at 10 ppm.	Walker, et al (1966)
3'-chloro-2-nitrobenz-anilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	10.0 (K2) (O)	a	Comment same as above except that at 10.0 ppm the chemical was toxic to 6 out of 10 goldfish at 48 hours.	Walker, et al
2'-chloro-3-nitrobenz-anilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	10.0 (K2) (O)	a	Comment same as above except that at 10 ppm the chemical was toxic to 1 out of 10 fish in 48 hours.	Walker, et al (1966)
2'-chloro-4-nitrobenz-anilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	(O) (O)	a	Comment same as above except that at 10 ppm this chemical was not toxic to trout or goldfish.	Walker, et al (1966)
3'-chloro-3-nitrobenz-anilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	10.0 (K 3 hr) 10.0 (K2)	a	Comment same as above except data cited.	Walker, et al (1966)
3'-chloro-4-nitrobenz-anilide	*Salmo gairdneri* *Carassius auratus*	BSA	–	(O) (O)	a	Comment same as above except that no fish were killed at 10 ppm.	Walker, et al (1966)

4'-chloro-2-nitrobenzanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	10.0 (K2) 10.0 (K2)	a	Comment same as above except data cited.	Walker, et al (1966)
5'-chloro-4-nitrobenzanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	10.0 (K2) (O)	a	Comment same as above except that at 10.0 ppm the chemical was toxic to 6 out of 10 goldfish in 48 hours.	Walker, et al (1966)
3'-chloro-3-nitro-p-benzotoluidide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	(O) (O)	a	Comment same as above except that chemical precipitated at 10 ppm, and the chemical was not toxic to trout. At 0.1 ppm the chemical was toxic to 1 out of 10 goldfish.	Walker, et al (1966)
5'-chloro-2-nitrophenol (free phenol)	*Petromyzon marinus*	BSA	–	3 (K 100%)	a	Mortality occurred in approximately 24 hr. This was a study on controlling sea lamprey larvae.	Ball (1966)
	Salmo gairdnerii	BSA	–	5 (K 10%)	a		
	S. trutta	BSA	–	5 (K 10%)	a		
Chloronitropropane	*Protococcus* sp *Chlorella* sp *Dunaliella euchlora* *Phaeodactylum tricornutum* *Monochrysis lutheri*	BSA	–	80 (K) 80 (K) 80 (K) 80 (K) 80 (K)	a	This paper concerns the growth of pure cultures of marine plankton in the presence of toxicants. Results were expressed as the ratio of optical density of growth in the presence of toxicants to optical density in the basal medium with no added toxicants.	Ukeles (1962)
5'-chloro-3-nitro-o-salisylanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	1.0 (K3A) 10.0 (K3A)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogen and their relative position(s) in the molecule.	Walker, et al (1966)
2'-chloro-5-nitrosalicylanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	10.0 (K 3 hr) 10.0 (K 3 hr)	a	Comment same as above.	Walker, et al (1966)
3'-chloro-3-nitrosalicylanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	1.0 (K2) 10.0 (K 3 hrs) 10.0 (K 3 hrs) 1.0 (K2)	a	Comment same as above.	Walker, et al (1966)
4'-chloro-3-nitrosalicylanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	1.0 (K 3 hr) 0.1 (K2) 1.0 (K 3 hr)	a	Comment same as above.	Walker, et al (1966)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
4'-chloro-5-nitrosalicyl-anilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	1.0 (K2) 1.0 (K2) 10.0 (K 3 hr)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule.	Walker, et al (1966)
3'-chloro-2-nitro-o-benz-otoluidide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	(O) (O)	a	Comment same as above except that this chemical was not toxic to trout or goldfish at 10 ppm.	Walker, et al (1966)
3'-chloro-3-nitro-o-salicylotolu-idide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	1.0 (K2) 10.0 (K 3 hr) 10.0 (K2)	a	Comment same as above except data cited.	Walker, et al (1966)
6'-chloro-3-nitro-o-salicy-lotoluidide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	10.0 (K2) (O)	a	Comment same as above except that this chemical was not toxic to goldfish at 10 ppm.	Walker, et al (1966)
4'-chloro-3-nitro-o-salicyl-otoluidide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	1.0 (K 3 hr) 10.0 (K 3 hr)	a	Comment same as above except data cited.	Walker, et al (1966)
2'-chloro-3-nitro-p-sa-licylotoluidide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	1.0 (K 3 hr) 1.0 (K 3 hr)	a	Comment same as above.	Walker, et al (1966)
Chlorophenol (meta)	Minnows	BSA	–	18.0 (T1A)	e	In the halophenols, the ortho was less toxic than the meta or para. All of the monohalophenols were less toxic than the 2,4,6-trihalophenols. Some data on biodegradability of halophenols were presented.	Ingols and Gaffney (1965)
o-chloro-phenol	*Lepomis macrochirus*	BSA	–	8.1 (T2A)	a c d e f g i o	Assays are completely described and autopsy data are reported.	Lammering and Burbank (1961)
o-chloro-phenol	*Pimephales promelas* *Lepomis macrochirus* *Carassius auratus* *Lebistes reticulatus*	BSA	–	12 (T4A) 10 (T4A) 14 (T4A) 23 (T4A)	a c d	Most fish survived at test concentrations of about one half or slightly more of the TL_m value. No attempt was made to estimate 100 percent survival.	Pickering and Henderson (1966)

Chlorophenol (ortho)	Minnows	BSA	–	58 (T1A)	e	In the halophenols, the ortho was less toxic than the meta or para. All of the monohalophenols were less toxic than the 2,4,6-trihalophenols. Some data on biodegradability of halophenols were presented.	Ingols and Gaffney (1965)
p-chlorophenol	*Hyborhynchus notatus*	BSA	–	(O)	–	Fish in aquaria were trained to detect and distinguish between phenol and p-chlorophenol at levels as low as 0.0005 ppm. The fish could also distinguish o-chlorophenol from the two other compounds. The training method is described.	Hasler and Wisby (1949)
Chlorophenol (para)	Minnows	BSA	–	14 (T1A)	e	In the halophenols, the ortho was less toxic than the meta or para. All of the monohalophenols were less toxic than the 2,4,6-trihalophenols. Some data on biodegradability of halophenols were presented.	Ingols and Gaffney (1965)
3-(p-chloro-phenol)-1,1-dimethyl-urea	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – PT (7), T (21) Ma – T So – T (7), PT (21) Cv – T (3), PT (14) Gp – T Np – T	Palmer and Maloney (1955)
Bis (p-chloro-phenoxy) methane	Bluegill	BSA	–	(O)	–	No mortality occurred at 0.05 ppm and very low mortality at 0.10 ppm. All fish died when the concentration was 0.2 ppm.	Linduska and Surber (1948)
P-chloro-phenyl-p-chloroben-zenesulfamate	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – PT (3) Ma – PT (14) So – PT (7) Cv – NT Gp – PT (7) Np – T (3)	Palmer and Maloney (1955)
3-chloro-propene	*Pimephales promelas*	BSA	–	24 (T4A)	a c d	Most fish survived at test concentrations of about one half, or slightly more, of the TL_m value. No attempt was made to estimate 100 percent survival.	Pickering and Henderson (1966)
	Lepomis macrochirus			42 (T4A)			
	Carassius auratus			22 (T4A)			
	Lebistes reticulatus			48 (T4A)			

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
4, chloro-o-toloxy-acetic acid	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – T (3) Ma – NT So – NT Cv – NT Gp – T (3) Np – T (3)	Palmer and Maloney (1955)
Chromic acid	*Daphnia magna*	BSA	–	$<$0.6 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes determined by the use of *D. magna.* Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Chromic chloride	*Daphnia magna*	BSA	–	$\ll$3.6 (S)	a	Lake Erie water was used as diluent. Toxicity given as threshold concentration producing immobilization for exposure periods of 64 hr.	Anderson (1948)
Chromic sulfate	*BOD*	L	–	1.0 (O)	j	"Toxicity" is expressed as 10 percent reduction in oxygen utilization.	Ingols (1955)
Chromic sulfate	Sewage organisms	BOD	–	(O)	–	Chromate ion is less toxic than chromic. 1.0 ppm produced a 10% oxygen depletion as compared to a control, and 10 ppm produced a 30% depletion.	Ingols (1954)
Chromic sulfate	Sewage organisms	BOD	–	117 (TC_{50})	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Chromic sulfate	*Daphnia magna*	BSA	–	0.1 (T1A) 0.03 (T2A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Chromic sulfate plus sodium dichromate	*Lymnaea sp (eggs)*	BSA	–	0.2 (T1A)	a c	Comment same as above.	Dowden and Bennett (1965)
Chromium, hexavalent	Bluegill, pumpkinseed sunfish, and orangespots	F	Woodstock, Ill.	(O)	c	At chromium concentrations above 50 ppm, the range of survival was such that no general curve could be applied to the data plotted on the chart.	Klassen, et al (1948)

Chromium	*Chlorococcum variegatus* *C. humicola* *Scenedesmus obliquus* *Lepocinclis steinii*	L	–	6.4-16.0 (O) 3.2-6.4 (O) 3.2-6.4 (O) 0.32-1.6 (O)	a	Chromium as dichromate was evaluated in two different tests. The concentrations reported are a range which completely inhibited growth for 56 days. Concentrations as low as 0.0001 to 0.032 ppm stimulated growth up to 33 days of *C. humicola, S. obliquus,* and *L. steinii*. Data for a flagellate and two diatoms are also presented.	Hervey (1949)
Chromium (hexavalent)	*Salmo gairdnerii*	L	–	2.5 (O)	a	For accumulation studies, fish were exposed for periods up to 24 days. For elimination studies, fish were exposed for 12 days, then placed in fresh water from 5 to 25. Chromium in the blood never exceeded the concentration of the surrounding water. All other tissues except muscle accumulated concentrations in excess of that in the water. Chromium was eliminated rapidly from blood, liver, stomach, pyloric caeca, and posterior gut. The spleen lost little of its chromium even after being in fresh water for 25 days. The kidney lost about 50% of its chromium in 25 days of fresh water exposure.	Knoll and Fromm (1960)
Chromium (hexavalent)	*Lepomis macrochirus*	BSA	–	110 (T4A)	a c d f q	Soft water was used. Alkalinity and hardness significantly reduced the toxicity of hexavalent chromium.	Trama and Benoit (1960)
Chromium (as chromate)	*Salmo gairdnerii*	BSCH	–	5 (K15)* 10 (K15)** 12.5 (K15)** * 40% kill **80% kill	a	This study is concerned with the measurement of chromium in trout before and after exposure. Chromium uptake is passive, and the amount accumulated is dependent on the concentration in water and duration of exposure.	Fromm and Stokes (1962)
Chromium	*Salmo gairdnerii*	L	–	2.5 (O)	–	Trout were exposed to 2.5 ppm of chromium as chromate in tap water for one week. The *in vitro* glucose transport by gut segments from these animals was compared to that of segments from untreated fish. The values from the treated animals was 40 percent lower than the controls.	Stokes and Fromm (1965)
Chromium	Rainbow trout	FR	Scotland	20 (NTE)	a c e f l m	This work represents an extension of laboratory studies of the toxicity of complex effluents to investigations of rivers.	Herbert, et al (1965)
Chromium	*Gasterosteus aculeatus*	BSA	–	1.0 (O)	a c e	This is a discussion of a bioassay method using stickleback fish and spectrophotometric determinations of the chemicals evaluated. The number listed is said to be the "toxic limit" for the fish.	Hawksley (1967)
Mixture: Chromium (a)- naphthenic acids (b)-cyanide (c) --------Mixture	*Lepomis macrochirus*	BSA	–	(a) 0.019 (T4A) (b) 4.74 (T4A) (c) 0.26 (T4A)	a c d e	All fish were acclimatized for 2 weeks in a synthetic dilution water.	Cairns and Scheier (1968)
Chromium chloride	Sewage organisms	BOD	–	0.18 (O)	–	Various metal salts were studied in relation to how they affected the BOD of both raw and treated sewage as well as how they affected the processing of sewage in the treatment plant. BOD was used as the parameter to measure the effect of the chemical. The chemical concentration cited is the ppm required to reduce the BOD values by 50%. This chemical was tested in an unbuffered system.	Sheets (1957)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Chromium chromate	*Lepomis macrochirus*	BSA	–	170 (T4A)	a c d f q	Soft water was used. Alkalinity and hardness significantly reduced the toxicity of this form of chromium.	Trama and Benoit (1960)
Chromium dichromate	*Lepomis macrochirus*	BSA	–	113 (T4A)	a c d e	All fish were acclimatized for 2 weeks in a synthetic dilution water.	Cairns and Scheier (1968)
Chromium oxide	Sewage organisms	BOD	–	4.0 (O)	–	The purpose of this experiment was to determine whether there was a constant relationship between the responses of these organisms. From the data presented, there was no apparent relationship of this type. Therefore the authors advise that bioassays on at least 3 components of the food web be made in any situation.	Sheets (1957)
Chromium potassium sulfate	*Pimephales promelas* *Lepomis macrochirus* *Carassius auratus* *Lebistes reticulatus*	BSA	–	(S) 5.07 (T4A) (H) 67.4 (T4A) (S) 7.46 (T4A) (H) 71.9 (T4A) (S) 4.10 (T4A) (S) 3.33 (T4A)	c d e f	(S) Soft water (H) Hard water Values are expressed as mg/l of chromium.	Pickering and Henderson (1965)
Chromium sulfate	*Gasterosteus aculeatus*	BSA	–	1.2 (K10)	–	Solutions were made up in tap water. 3.0 to 5.0 cm stickleback fish were used as experimental animals. This paper points out that there is a marked relationship between the toxicity of the metals and their solution pressures. Those with low solution pressures were the most toxic.	Jones (1939)
Citric acid	*Daphnia magna*	BSA	–	153 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Citric acid	*Biomorpholaria a. alexandrina* *Bulinus truncatus* *Lymnaea caillaudi*	BSA	–	1200 (K1A) 1000 (K1A) 800 (K1A)	a	The degree of tolerance for vector snails of biharziasis chemicals is somewhat dependent upon temperature. The temperature at which (K1A) occurred was 27 C for *Bulinus* and *Biomphalaria* and 28 C for *Lymnaea*.	Gohar and El-Gindy (1961)
Cobalt	*Lebistes reticulatus* *Bufo valliceps* (tadpoles) *Daphnia magna*	L	–	100.0 (K) 100.0 (K) 50.0 (K)	a c e	It is assumed in this experiment that the cations considered are toxic because they combine with an essential sulfhydryl group attached to a key enzyme. This treatment indicates that the metals which form the most insoluble sulfides are the most toxic. The log of the concentration of the metal ion is plotted against the log of the solubility product constant of the metal sulfide — a treatment that does not lend itself to tabulation. The cation toxicity cited is only an approximate concentration interpolated from a graph. Time of death was not specified.	Shaw and Grushkin (1967)

Cobalt chloride	*Daphnia magna*	BSA	–	<3.1 (S)	a	Lake Erie water was used as diluent. Toxicity given as threshold concentration producing immobilization for exposure periods of 64 hr.	Anderson (1948)
Cobalt chloride	Sewage organisms	BOD	–	64.0 (TC_{50})	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Cobalt chloride	*Limnaea palustris* (eggs)	BSA	–	4 x 10^{-5} M (K1)	a c	Toxicity is given in molar concentrations for maximum direct mortality (kill) in 4 hours.	Morrill (1963)
Cobaltous chloride	*Daphnia magna*	BSA	–	<26 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Cobalt nitrate	*Gasterosteus aculeatus*	BSA	–	10 (K10)	–	Solutions were made up in tap water. 3.0 to 5.0 cm stickleback fish were used as experimental animals. This paper points out that there is a marked relationship between the toxicity of the metals and their solution pressures. Those with low solution pressures were the most toxic.	Jones (1939)
Copper	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, possible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compares this work with earlier work, and lists an extensive bibliography. In water distilled from a copper still with block-tin leads, the fish survived 352 to 597 minutes – perhaps the effect of copper.	Powers (1918)
Cu	*Nemacheilus barbatulus*	BCH BCH	England England	0.28 (K) 0.20-0.30 (K)	–	Fresh water input was through Cu pipes into an aquarium. All fish died within 24 hours at concentrations of 0.20 ppm and above.	Mackereth and Smyly (1951)
Copper ion (copper chloride and copper sulfate	*Lepomis macrochirus*	BSA	–	0.74 (T4A) 0.94 (T2A)	a c d e	Modified Chu 14 diluent made of distilled water was used with aeration toxicity of copper ion was found to be dependent upon pH. Below pH 5.3, all copper is in solution, above this the copper precipitates and is less toxic.	Trama (1954)
Copper	Sewage organisms	BOD	–	(O)	–	Copper was more toxic than zinc in all concentrations from 0.1 to 10.0 ppm. The presence of the element could result in errors in BOD tests. At 1.0 ppm the oxygen demand in percent of the control was 65%.	Ingols (1956)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Copper	*Chlorella vulgaris*	L	–	(O)	a c e	This was a respiration study using a shake culture technique. 10^{-1} M copper sulfate was not inhibitory for 7-20 hours. Concentrations of 10^{-3} M copper sulfate were toxic to unshaken cultures.	Hassall (1962)
Copper	*Nereis* sp	BSA	–	1.5 (K2-3) 0.5 (K4)	a	The threshold of copper for *Nereis* worms was about 0.1 ppm.	Raymont and Shields (1964)
	Carcinus maenas			(O)		The copper toxicity threshold for the shore crab was 1-2 ppm.	
	Leander squilla			(O)		The copper toxicity threshold for prawns was below 0.5 ppm.	
Copper	*Salmo salar*	BCFA	–	0.034 (T1A)	a c f	The laboratory water in which the experiment was performed contained 3 μg/liter of zinc, as judged by analyses over several years, and 2 μg/liter of copper. Lethal concentrations of mixtures activities or three times as fast as the metals singly, a somewhat greater potentiation than was found in the previous tests with salmon.	Sprague (1965)
Copper	Rainbow trout	FR	Scotland	0.8 (T2)	a c e f l m	This work represents an extension of laboratory studies of the toxicity of complex effluents to investigations of rivers.	Herbert, et al (1965)
Copper	*Gasterosteus aculeatus*	BSA	–	0.02 (O)	a c e	This is a discussion of a bioassay method using stickleback fish and spectrophotometric determinations of the chemicals evaluated. The number listed is said to be the "toxic limit" for the fish.	Hawksley (1967)
Copper	*Orconectes rusticus*	BCFA	–		a c e f	All experiments were conducted at 20 C.	Hubschman (1967)
				3.0 (T4A)		Crayfish in the intermolt adult stage.	
				1.0 (T1A)		Adult crayfish.	
				1.0 (K_6)(T6A)		Juvenile crayfish.	
				1.0 (T_6)(T6A)		Recently hatched young which remained clinging to pleopods of the female during the first molt.	
						An acute toxicity threshold existed between 0.6 and 0.125 mg/l for newly hatched young. At a concentration of 1 mg/l, 50% mortality among newly hatched young was reached with an exposure time of 1/50th required for adults.	
Copper	*Lebistes reticulatus*	BSA	–	1.0 (K)	a c e	It is assumed in this experiment that the cations considered are toxic because they combine with an essential sulfhydryl group attached to a key enzyme. This treatment indicates that the metals which form the most insoluble sulfides are the most toxic. The log of the concentration of the metal ion is plotted against the log of the solubility product constant of the metal sulfide — a treatment that does not lend itself to tabulation. The cation toxicity cited is only an approximate concentration interpolated from a graph. Time of death was not specified.	Shaw and Grushkin (1967)
	Bufo valliceps (tadpoles)			0.1 (K)			
	Daphnia magna			0.1 (K)			

Copper	*Pimephales promelas*	BCFCH	–	0.43 (T4A)	a c d e f	The paper discusses growth rate, number of spawnings, number of eggs produced and hatchability of eggs in water containing 4.4 to 95 ppm copper. Results indicated that the sublethal concentrations of copper affecting growth and reproduction lies between 3 and 7 percent of the 96-hr median tolerance limit.	Mount (1968)
Copper	*Salmo gairdnerii*	BSA	–	0.4 to 0.5 (T2A)	a c d e f	The concentration killing a half batch of fish in 2 days provides a reasonable estimate of the threshold concentration. The lethality of this chemical depends upon the total hardness and dissolved oxygen concentration.	Brown (1968)
Copper (Cu^{++})	*Lepomis macrochirus*	BSA	–	1.25 (T4A)	a c d e	All fish were acclimatized for 2 weeks in a synthetic dilution water.	Cairns and Scheier (1968)
Copper (a)-acetic acid (b)-acetaldehyde (c)-acetone (d) mixture	*Lepomis macrochirus*	BSA	–	(a) 1.04 (T4A) (b) 26.0 (T4A) (c) 5.2 (T4A) (d) 5.2 (T4A)	a c d e	Comment same as above.	Cairns and Scheier (1968)
Copper para-amino benzoate	*Balanus eberneus*	BSA	–	0.9 (O)	–	The concentration listed was lethal to 90% of adult barnacles in 2 days.	Clarke (1947)
Copper carbonate (basic)	*Balanus balanoides* *Balanus eberneus*	BSA	–	0.41 (O) 0.28 (O)	–	The concentration listed was lethal to 90% of adult barnacles in 2 days.	Clarke (1947)
Copper citrate	*Balanus balanoides* *Balanus eberneus*	BSA	–	0.60 (O) 0.55 (O)	–	Comment same as above.	Clarke (1947)
Copper cyanide complex	*Lepomis macrochirus* (juveniles)	BSA	–	4.0 (O)	a c d f p	For the concentration given, the median resistance time was 226 minutes.	Doudoroff, et al (1966)
Copper cyanide complex Sodium cyanide (533 ppm CN^-) and Cupric sulfate (427 ppm Cu)	*Pimephales promelas*	BSA	–	1.5 (T4) CN^- 1.2 (T4) Cu	a c	Synthetic soft water was used. Toxicity data given as number of test fish surviving after exposure at 24, 48, and 96 hr. TL_m values were estimated by straight-line graphical interpolation and given in ppm CN^-.	Doudoroff, et al (1956)
Copper disodium versenate	Channel catfish (fingerlings)	BSA	–	1881 (K 25 hr A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Copper naphthenate	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – PT (7) Ma – T (3) So – PT (3) Cv – PT (3) Gp – T (7), PT (14) Np – NT	Palmer and Maloney (1955)
Copper nitrate	*Gasterosteus aculeatus*	BSA	–	1.0 (T6.5A)	a c	Death of the fish resulted from an interaction between the metallic ion and the mucus secreted by the gills. Coagulated mucus formed on the gill membranes and impaired respiration to such a degree that the fish asphyxiated.	Jones (1938)
Copper salicylate	*Balanus eberneus*	BSA	–	0.90 (O)		The concentration listed was lethal to 90% of adult barnacles in 2 days.	Clarke (1947)
Copper salts	*Salmo gairdnerii*	BSA	–	(O)	a e	This is a study of the effect of varying dissolved oxygen concentration on the toxicity of selected chemicals. The toxicity of heavy metals, ammonia, and monohydric phenols increased as the dissolved oxygen in water was reduced. The most obvious reaction of fish to lowered oxygen content is to increase the volume of water passed over the gills, and this may increase the amount of poison reaching the surface of the gill epithelium. The concentration of the chemical in the water was not specified.	Lloyd (1961)
Copper salt plus citrate	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – T (3) Ma – T (3) So – PT (7) Cv – T (3) Gp – T (3) Np – T (3)	Palmer and Maloney (1955)
Copper sodium citrate	*Artemia salina* *Acartia clausi* *Elminus modestus*	BSA	–	0.005 (O) 0.01 (O) 0.002 (O)	a c	All tests were conducted in seawater. Toxicity values reported are relative to that of mercuric chloride expressed as unity. Mechanism of action is discussed, as well as synergistic action of two poisons administered simultaneously.	Corner and Sparrow (1956)

Copper tartrate	*Balanus balanoides*	BSA	–	0.58 (O)	–	The concentration listed was lethal to 90% of adult barnacles in 2 days.	Clarke (1947)
Copper and zinc	Atlantic salmon	FR	Canada	(O)	f	"Toxicity index" for copper and zinc combined was described in connection with disturbed salmon migration. Toxicity index > 1.0 indicates lethality to "young salmon after long exposure". A toxicity index of 0.15 or 15% of lethal concentration of copper and zinc seemed to be the maximum safe level for salmon migration.	Sprague (1964)
Copper and zinc	*Salmo salar*	BSA	–	0.048 Cu (O) 0.600 Zn	a	The values given are for an ILL (incipient lethal level) and in this instance only in water of 20 mg/liter of hardness. Concentrations above this are lethal in about one day. These values were determined by bioassay. Salmon parr in the laboratory avoided less than one tenth of incipient lethal levels. Avoidance thresholds were 0.09 ILL of zinc, 0.05 ILL of copper and 0.02 ILL of equitoxic mixtures. In equitoxic mixtures of these compounds, the ILL was additive.	Sigler, et al (1966)
Copper chloride	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, possible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compares this work with earlier work, and lists an extensive bibliography. In a concentration of 0.66N, fish survived 78 minutes; at a concentration of 0.0000011N, fish survived 300 minutes – truly a very wide variation.	Powers (1918)
Copper chloride (tech)	Bluegill	BSA?	–	0.980 (T4A)	a	This is an estimated LC_{50} value at temperatures from 55 to 75 F.	Cope (1965)
Copper chloride	*Nitzschia linearis* *Lepomis macrochirus*	BSA	–	0.795-0.815 (T5A) 1.25 (T4A)	a c e	The purpose of this experiment was to determine whether there was a constant relationship between the responses of these organisms. From the data presented, there was no apparent relationship of this type. Therefore the authors advise that bioassays on at least 3 components of the food web be made in any situation.	Patrick, et al (1968)
Copper sulfate	Algae zooplankton		Lakes in Wisc.	(O)	a e g l n	Copper sulfate was applied when deemed necessary to control algae (0.50 pounds of copper sulfate per million gallons of water). Applications of copper sulfate were made as required over an eleven-year period. Zooplankton was not effected by these applications. The spray applied for control of algae also kept fish fungal diseases under control.	Domogalla (1935)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Copper sulfate	*Morone americana*	FL	4 lakes, Nova Scotia	1 (K)	a c d f	The work was undertaken to test the feasibility of utilizing poisons as a direct means of studying the production of fish in streams and lakes. Caution must be used to prevent irreparable damage by indiscriminate poisoning.	Smith (1939)
	Perca flavescens			1 (K)			
	All fish			3 (K)			
	Mesocyclops obsoletus			3 (SB)			
	Macrobdella decora			3 (SB)			
	Nymphaea			3 (NTE)			
	Juncus			3 (NTE)			
	Pontederia			3 (NTE)			
	Scirpus			3 (NTE)			
	Eriocaulon			3 (NTE)			
	Potamogeton			3 (NTE)			
	Algae			3 (NTE)			
Copper sulfate	*Morone americana*	FL	4 lakes, Nova Scotia	1 (K)	a c d f	Comment same as above.	Smith (1939)
	Perca flavescens			1 (K)			
	All fish			3 (K)			
	Mesocyclops obsoletus			3 (SB)			
	Macrobdella decora			3 (SB)			
	Nymphaea			3 (NTE)			
	Juncus			3 (NTE)			
	Pontederia			3 (NTE)			
	Scirpus			3 (NTE)			
	Eriocaulon			3 (NTE)			
	Potamogeton			3 (NTE)			
	Algae			3 (K)			
Copper sulfate	Smallmouth black bass *Chara* sp	FL	Leetown, Va.	2.0 (O)	d	Treatment of a series of ponds resulted in control of *Chara* spp but no or slight fish kill due to copper sulfate. Some kill occurred because of suffocation caused by decaying vegetation.	Surber and Everhart (1950)
Copper sulfate	*Pygosteus pungitius*	BCF	–	(O)	a c	Fish were exposed to 0.1, 0.04, and 0.01N copper sulfate. pH of the solutions was 5.0, 5.4, and 5.8. Survival times were 55, 62, and 75 minutes, respectively.	Jones (1947)
Copper sulfate (anhydrous)	*Lymnaeid* snails	BSA	–	1.0 (K1A)	–	Each tast container (500-ml beaker) was filled with ditch water.	Batte, et al (1951)

Copper sulfate	*Tendipes plumosus* *Pisidium idahoense* and other bottom-dwelling organisms	FL & BSA	Wisc.	(O)	–	The bottom muds of Lake Morona contained up to 480 milligrams of copper per kilogram of mud on a dry-weight basis. Lakes Nagawicka and Pewaukee contain up to 22 and 55, respectively. All contained thriving populations of aquatic organisms despite years of $CuSO_4$ application for algal control. From laboratory bioassays of muds containing $CuSO_4$, it was concluded that 9,000 parts per million copper on a dry-weight basis precipitated and accumulated in bottom muds was toxic to bottom organisms. From the results of these studies, it is indicated that differences occurring in the population density of bottom organisms in the four lakes studied are due to ecological variables within these separate bodies of water.	Mackenthun and Cooley (1952)
Copper sulfate	*BOD*	L	–	1.0 (O)	j	"Toxicity" is expressed as 39 percent reduction in oxygen utilization.	Ingols (1955)
Copper sulfate	*Microcystis aeruginosa*	L	–	100 (K)	a	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
Copper sulfate	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – PT (7), T (14) Ma – T (3) So – PT (7) Cv – T (3) Gp – T (3) Np – T (3)	Palmer and Maloney (1955)
Copper sulfate (with stabilizing agent)	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Comment same as above except that Cl – T (3) Ma – T (3) So – PT (3) Cv – T (3) Gp – T (3) Np – T (3)	Palmer and Maloney (1955)
Copper sulfate	*Pimephales promelas*	BSA	–	0.18 (T4A)	a c d e f	Toxicity to 30 species of algae is also presented. $CuSO_4$ was algicidal in the range 0.5 to 2.0 ppm.	Palmer and Maloney (1956)
Copper sulfate	Sewage organisms	BOD	–	0.4 (O)	–	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 7.0. Solutions were renewed every 12 hours.	Sheets (1957)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Copper sulfate	*Gambusia affinis*	BSA	–	84 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Copper sulphate	*Salmo gairdneri* (fry)	BSA	–	3.8 (T1A) 10 (O)	a c e f i p	Five hatchery troughs were employed with 6 Imperial gallons (27.276 liters) of hatchery water. The water used in the experiments was reportedly typical of Inyanga Rhodesia trout streams and dams. Concentrations of 10 ppm of copper sulphate caused 90-100% mortality.	Turnbull-Kemp (1958)
Copper sulfate	*Salvelinus fontinalis x Salmo trutta*	FPA	N.Y.	1.0 (S23)	a c d	Conventional farm ponds were used having an average surface area of 0.3 acre and a maximum depth of 7-9 ft. Toxicity (in ppm) to fish as maximum safe concentration (S) for 23 days was determined. Concentration of 0.5 ppm was required to control algae.	Eipper (1959)
	Notemigonus crysoleucas			1.0 (K)			
	Micropterus salmoides			1.0 (S23)			
	Lepomis macrochirus			1.0 (S23)			
Copper sulfate	Sewage organisms	BOD	–	21 (TC_{50})	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Copper sulfate	*Pimephales promelas*	BSA	–	(H) 1.4 (T4A) (S) 0.05 (T4A)	a c d f	Both hard (H) and soft (S) water were used.	Tarzwell and Henderson (1960)
	Lepomis macrochirus			(H) 10 (T4A) (S) 0.2 (T4A)			
Copper sulfate	*Limnodrilus hoffmeisteri*	BSA	–	0.40 (T4A)	a c d i	Hard water only was used in this study for all but *T. decorus* which was also studied in soft water.	Wurtz and Bridges (1961)
	Gyraulus circumstriatus			0.425 (T4A)			
	Physa heterostropha			0.27 (T4A)			
	Tendipes decorus			1.0 (K 60%) 0.032 (K 40%)			
Copper sulfate	*Rana pipiens*	BSCH	–	16 (K)	a c	$CuSO_4$ was toxic to this frog at various temperatures in concentrations >0.0015 percent.	Kaplan and Yoh (1961)
Copper sulfate	*Physa heterostropha*	BSA	–	0.56 (T1A)	a c f	These tests were conducted in hard and soft water. Data indicated small if any differences in toxicity of copper sulfate due to water hardness.	Wurtz (1962)

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Copper sulfate	*Microcystis* sp Zooplankters Copepods Cladocerans Rotifers Chaoboridae Ostracods etc.	FL	Auburn, Ala.	0.5-0.8 (O)	d	In a series of ponds, $CuSO_4$ at the indicated concentration range reduced the growth of *Microcystis* spp by as much as 95 percent in 5-20 days. This reduction lasted for as long as 30 days in some cases. According to the authors, generally there was an inverse relation between the abundance of *Micrycystis* and the number of zooplankters.	Crance (1963)
Copper sulfate	*Nais* spp	BSA	–	1.0 (K)	a f	Around pH 7.0, copper was more toxic in soft than in hard water. At 1.00 ppm the average median survival time for the worms was reduced from 70 to 35 minutes. It is interesting that copper is less toxic at a pH of 4.0 than at 7.0.	Learner and Edwards (1963)
Copper sulfate	*Chlorella pyrenoidosa*	L	–	20 (AS1)	–	Describes a bioassay method to differentiate between an algicide (AC) and an algistat (AS). The treated culture was subcultured as time progressed. Allen's medium was used.	Fitzgerald and Faust (1963)
Copper sulfate (Algeaclear) (Cuprose)	*Microcystis aeroginosa* *Chlorella pyrenoidosa* *Anabaena circinalis* *Gloeotrichia echinulata* *Phormodinium inundatum*	L	–	(O)	c e	Different sources of copper appeared to be equally effective as toxic agents for algae. The medium in which toxicity tests are carried out had a great influence on the toxicity of copper. It was pointed out that in copper compounds, the range in toxic action can vary from algicidal activity at concentrations of 0.05 to 0.4 ppm of $CuSO_4$, or algistatic activity at 2 to 24 ppm of $CuSO_4$ with certain algae, to situations in which the growth of algae is only slightly inhibited by a concentration of copper sulfate as high as 30 ppm.	Fitzgerald and Faust (1963)
Copper sulfate	*Gammarus lacustris*	BSA	–	1.5 (T4A)	a e	Emulsible concentrates were prepared from technical grade insecticides with acetone as the solvent. Symptoms prior to death were observed and recorded on graphs.	Nebeker and Gaufin (1964)
Copper (copper sulfate)	*Salmo salar*	BCF	–	0.048 (O)	a c d e f	The experiments were carried out in soft water. Values are reported as micrograms of metal and toxicity as LT_{50}. In solutions containing copper and zinc, fish died twice as fast as would occur if the two metals were simply additive in their lethal action.	Sprague (1964)
Copper sulfate	*Salmo salar*	BSA	–	(O)	a c d e f	The EC_{50} or the effective concentration that elicited as avoidance reaction in the fish was 0.052 x the ILL (incipient lethal level), or 0.052 x 44 µg/L, or 2.28 µg/L.	Sprague (1965)
Copper sulfate	*Pimephales promelas* *Lepomis macrochirus* *Carassius auratus* *Lebistes reticulatus*	BSA	–	(S) 0.025 (T4A) (H) 1.76 (T4A) (S) 0.66 (T4A) (S) 0.036 (T4A) (S) 0.036 (T4A)	c d e f	(S) Soft water (H) Hard water Values are expressed as mg/l of metal.	Pickering and Henderson (1965)
Copper sulfate	Carp Tench Ephemeropterae larvae Trichopterae larvae	FR	France	0.1 (75% K6) 0.2 (75% K6) 0.2 (100% K)	–	Field studies conducted. Two streams were studied; one was used for testing, the other for control. Trichopterae were not affected, i.e., they were active even at concentrations of 0.30 ppm.	Vivier and Nisbet (1965)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Copper sulfate	*Helix pomatia*	BSA	—	0.01-0.1 (O)	c	This paper was concerned with the effect of the chemical on mucous secretion in the snail. Snails exposed to the indicated copper sulfate solutions showed severe signs of toxicity. There was an increase in mucous secretion and the animals did not respond to tactile stimuii.	de Calventi (1965)
Copper sulfate (tech)	Bluegill	BSA	—	2.8 (T4A)	a	This is an estimated LC_{50} value at temperatures from 55 to 75 F.	Cope (1965)
Copper sulfate	Blue-green algae *Cylindrospermum* *Anabaena* *Anacystis* *Calothrix* *Nostoc* *Oscillatoria* *Plectonema* Green algae *Ankistrodesmus* *Chlorella* *Closterium* *Oocystis* Green algae *Scenedesmus* *Stigeoclonium* *Zygnema* Green flagellate and yellow algae *Chlamydomonas* *Pandorina* *Tribonema* *Gomphonema* *Navicula* *Nitzchia*	L	—	2.0-4.0 (O)	—	$CuSO_4$ was generally toxic or partially toxic to blue-green algae for 28 days at the indicated concentrations. At 2.0 ppm, it was similarly toxic to the green algae, green flagellates, and yellow algae.	Kemp, et al (1966)
Copper sulfate	*Salmo gairdneri*	BSA	—	0.150 (T2A)	a	This paper reports acute toxicity of a number of compounds, and discusses sub-acute mortality as well. Effects on reproduction and behavior are also discussed. Data presented as EC_{50}.	Cope (1966)
	Lepomis macrochirus			2.800 (T2A)			
Copper sulfate	*Lepomis macrochirus*	FL	Various lakes, Michigan	13-140 (K)	a d	For controlling bluegill reproduction, copper sulfate crystals were directed toward nests where eggs and fry were the primary target. The estimated copper sulfate concentrations were estimated to be 13-140 ppm. All eggs and fry were dead in some 200 samplings. Fish other than bluegill fry apparently were not killed by this copper sulfate treatment. Treatment throughout the 3-month spawning period was required for significant reduction of the bluegill population.	Beyerle and Williams (1967)

Copper sulfate (as Cu)	*Salmo salar* *S. trutta* *S. Salmo gairdnerii*	BSCH	–	0.06 (K)	c f	The reported figure is a reported lethal concentrate as found in polluted lakes and streams in Norway. Organic matter apparently has a masking effect that reduces toxicity. 50% of rainbow trout eggs survived to hatch in 0.05 ppm of Cu. Rainbow trout and Atlantic salmon acted similarly to the chemical. Brown trout were slightly more resistant.	Grande (1967)
Copper sulfate plus zinc sulfate (various ratios)	*Salmo gairdnerii*	BSA	–	(O)	a e p	Both hard and soft water were used. Median period of survival in hard water was 3 days – 3.5 ppm Zn, and 1.1 ppm Cu; in soft water – 7 days, 0.56 ppm Zn and 0.044 ppm Cu.	Lloyd (1961)
Cresol	*Lepomis macrochirus*	BCFA	–	13.6 (T4A) small 10.9 (T4A) med. 10 (T4A) large	a c e f	Test water was composed of distilled water with CP grade chemicals and was aerated throughout the 96-hour exposure period.	Cairns and Scheier (1955)
Cresol	*Gambusia affinis*	BSA	–	24 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Cresol	*Lepomis macrochirus*	BSA	–	10.0 (T4A)	a c d e i	A "control" was prepared by adding required chemicals to distilled water, and this was constantly aerated. Data reported are for larger fish, app 14.24 cm in length. Data for smaller fish are also in the report.	Cairns and Scheier (1959)
Ortho-cresol	*Phoxinus phoxinus*	BCFA	–	0.04% (K 13 min)	a c	Tap water used as a diluent. The apparatus used was a 34 mm diameter tube fitted to permit sharp vertical separation of water and test solution. With this system, avoidance data could be obtained. Toxicity is given as average survival time of replicates. Fish avoided concentrations of 0.03 to 0.04%.	Jones (1951)
O-cresol	Sewage organisms	BOD	–	940 (TC_{50})	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
O-cresol	Channel catfish (fingerlings)	BSA	–	66.8 (K 69 hr A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
O-cresol	*Pimephales promelas* *Lepomis macrochirus* *Carassius auratus* *Lebistes reticulatus*	BSA	–	13 (T4A) 24 (T4A) 23 (T4A) 29 (T4A)	a c d e f	Most fish survived at test concentrations of about one half, or slightly more, of the TL_m value. No attempt was made to estimate 100 percent survival.	Pickering and Henderson (1966)
p-cresol	Fish	BSA	–	5.1×10^{-5} M (K)	a c	Avoidance behavior of test fish to toxic chemicals is given. Toxicity is given as the lowest lethal concentration (molar). Ratios of avoidance and lowest lethal concentration are presented and discussed.	Ishio (1965)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Cryolite	*Simocephalus serrulatus* *Daphnia pulex*	BSA	–	10.0 (SB) 5.0 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 48 hr. Data cited are for 60 F, but assays were performed at varied temperatures. "Water Chemistry" (Unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
Crystal violet	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
Cumene hydroperoxide	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T=toxic, NT=nontoxic, PT= partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – PT (7) Ma – T (7) So – NT Cv – PT (7) Gp – PT (7) Np – T (7)	Palmer and Maloney (1955)
Cupric ammonium chloride	*Daphnia magna*	BSA	–	0.039 (S)	a	Lake Erie water was used as diluent. Toxicity given as threshold concentration producing immobilization for exposure periods of 64 hr.	Anderson (1948)
Cupric chloride	*Daphnia magna*	BSA	–	0.08 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna.* Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Cupric chloride	*Daphnia magna*	BSA	–	0.027 (S)	a	Lake Erie water was used as diluent. Toxicity given as threshold concentration producing immobilization for exposure periods of 64 hr.	Anderson (1948)
Cupric citrate	*Mytilus edulis*	BSA	–	0.55 (O)	–	When the mussels were placed in the test solution for one day, and then in fresh sea water, they died in 2, 3, and 4 days.	Clarke (1947)
Cupric oxide	*Gambusia affinis*	BSA	–	56,000 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Cupric sulfate	*Daphnia magna*	BSA	–	0.1 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna.* Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)

Cyanide	*Mayorella palestinensis* (soil amoeba)	BSA	–	(O)	a c	The experiments were carried out in Warburg manometers at 27 C for 4 hr at a pH of 8.0. Cyanide in concentrations up to 5 x 10^{-3} M were shown to have lethal effects on the organism. Results were compared with controls and expressed in percent of respiration. Compared with normal respiration, nonlethal concentrations of cyanide increased the respiration of the organism in glucose-containing solutions. It was concluded that the respiration of the organism depends on at least three enzyme systems, which may be distinguished by their behavior toward cyanide.	Reich (1955)
Cyanide	*Lepomis auritus* *L. macrochirus* *Micropterus salmoides* *Pomoxis annularis*	BSA & CF	–	0.06 (T1SA) 0.01-0.06 (T<1SA) 0.05-0.06 (T<1CFA) 0.06 (T<11SA) 0.05-0.07 (T<1SA) 0.02-0.04 (T<1CFA)	a	Additional data for less than 24 hr are given and also for the disappearance and breakdown of cyanide in anaerobic soil systems.	Renn (1955)
Cyanide	Brown trout Small mouth bass	BSA BCF BCF	–	0.31-0.96 (O) 0.32-1.06 (O) 0.175-1.98 (O)	a c d e	The pH of the water varied from 7.5-8.28 in the test solutions. Dissolved oxygen was controlled by aeration. In the report, time of death is plotted against cyanide concentration. In a continuous flow apparatus, a range of concentrations from 0.32 to 1.06 ppm killed in 17-48 minutes and 4.2 to 15.2 minutes, respectively. In a static test, 0.31 to 0.96 ppm killed in 33-230 and 6.0-18.7 minutes, respectively. These data are for brown trout. For small mouth bass, in a continuous flow apparatus, concentrations of 1.98 ppm down to 0.175 ppm killed in 6-10 and 213-477 minutes respectively. The effect of dissolved oxygen is discussed.	Burdick, et al (1958)
Cyanide	*Lepomis macrochirus*	BSA	–	0.18 (T4A)	a c d e	All fish were acclimatized for 2 weeks in a synthetic dilution water.	Cairns and Scheier (1968)
Cyanide	*Physa heterostropha* *Lepomis macrochirus*	BSA	–	0.432 (T4A) 0.18 (T4A)	a c e	The purpose of this experiment was to determine whether there was a constant relationship between the responses of these organisms. From the data presented, there was no apparent relationship of this type. Therefore the authors advise that bioassays on at least 3 components of the food web be made in any situation.	Patrick, et al (1968)
Cyanide	*Lebistes reticulatus*	BSA	–	(O)	a c f n o	A series of equations was devised to describe the toxicity of a system containing two toxicants — zinc - zinc and cyanide. Concentrations of cyanide, 0.42 ppm, 0.28 ppm, and 0.26 ppm, killed 50 percent of the animals in 20, 30, and 43 hours, respectively. Toxicity of the two-component system was then determined using varying ratios of the two components.	Chen and Selleck (1968)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Cyanide	Fish (unidentified)	FR	Dunreith, Indiana	0.05-0.1 (K)	–	Tests for cyanide pollution were made following a train-car collision. Five tank cars carrying acetone cyanohydrin, vinyl chloride, ethylene oxide, and methyl methacrylate were involved.	Moore and Kin (1969)
Cyanide (a)-chromium (b)-naphthenic acids (c) mixture	*Lepomis macrochirus*	BSA	–	(a) 0.026 (T4A) (b) 0.019 (T4A) (c) 4.74 (T4A)	a c d e	All fish were acclimatized for 2 weeks in a synthetic dilution water.	Cairns and Scheier (1968)
Cyanide (a)-zinc (b)-mixture	*Lepomis macrochirus*	BSA	–	(a) 0.26 (T4A) (b) 3.90 (T4A)	a c d e	Comment same as above.	Cairns and Scheier (1968)
Cychohexane	*Gambusia affinis*	BSA	–	15,500 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Cyclohexane	*Pimephales promelas* *Lepomis macrochirus* *Carassius auratus* *Lebistes reticulatus*	BSA	–	30 (T4A) 31 (T4A) 33 (T4A) 48 (T4A)	a c d e f	Most fish survived at test concentrations of about one half, or slightly more, of the TL_m value. No attempt was made to estimate 100 percent survival.	Pickering and Henderson (1966)
1, cyano-1,3-butadiene	*Lagodon rhomboides*	BSA	–	71.5 (T1A)	a	Aerated seawater was used.	Daugherty and Garrett (1951)
1, cyano-1,3-butadiene	*Lagodon rhomboides*	BSA	–	71.5 (T1A)	–	Experiments were conducted in aerated salt water.	Garrett (1957)
Cymeme thiocyanate	Green sunfish	BSA	–	(O)	–	Fish were moderately repelled at concentrations of 20 mg/l but the response to 10 mg/l was indifferent. The chemical has apparent high toxicity.	Summerfelt and Lewis (1967)
2,4-diamino-phenol dihydro-chloride	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
2,4-diamino-phenol hydro-chloride	*Daphnia magna*	BSA	–	80 (K2)	a	An attempt was made to correlate the biological action with the chemical reactivity of selected chemical substances. Results indicated a considerable correlation between the aquarium fish toxicity and antiautocatalytic potency of the chemicals in marked contrast to their toxicity on systemic administration.	Sollman (1949)
Diamylamine	*Semotilus atromaculatus*	BSA	–	5 to 20 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)

2',5'-dibromo-3-nitrosalicylanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	1.0 (K2) 10.0 (K 3 hr) 10.0 (K 3 hr)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule.	Walker, et al (1966)
3,5-dinitro-2',3'-benzoxylidide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	(O) (O)	a	Comment same as above except that at 10.0 ppm the chemical was toxic to 1 out of 10 trout in 48 hr. At 10 ppm the chemical was not toxic to goldfish.	Walker, et al (1966)
4',5-dibromo-3-nitrosalicylanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	1.0 (K2) 10.0 (K 3 hr)	a	Comment same as above except data cited.	Walker, et al (1966)
Di-sec-butylamine	*Semotilus atromaculatus*	BSA	–	15 to 40 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
Di-n-butylamine	*Semotilus atromaculatus*	BSA	–	20 to 60 (CR)	a e	Comment same as above.	Gillette, et al (1952)
1,3-dibutylthiourea	*Semotilus atromaculatus*	BSA	–	30 to 100 (CR)	a e	Comment same as above.	Gillette, et al (1952)
Orthodichlorobenzene	*Protococcus* sp *Chlorella* sp *Dunaliella euchlora* *Phaeodactylum tricornutum* *Monochrysis lutheri*	BSA	–	13 (NG) 13 (NG) 13 (NG) 13 (NG) 13 (NG)	a	This paper concerns the growth of pure cultures of marine plankton in the presence of toxicants. Results were expressed as the ratio of optical density of growth in the presence of toxicants to optical density in the basal medium with no added toxicants. NG=no growth, but the organisms were viable.	Ukeles (1962)
2,6-dichlorobenzine acid (tech)	Rainbow trout Bluegill	BSA	–	140 (T4A) 120 (T4A)	a	This is an estimated LC_{50} value at temperatures from 55 to 75 F.	Cope (1965)
2,4-dichlorobenzylnicotinium chloride	*Microcystis aeruginosa*	L	–	5.0 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1×10^6 to 2×10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
1,2-dichloroethane	*Lagodon rhomboides*	BSA	–	150-175 (O)	–	Experiments were conducted in aerated salt water. Toxicity range given as the concentrations which produced <1/2 deaths and >1/2 deaths.	Garrett (1957)
3,6-dichloro-2,5-dimethoxybenzoquinone	*Microcystis aeruginosa*	L	–	75 (K)	a, etc	The chemical was tested on a 5-day-old algae culture, 1×10^6 to 2×10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
1,1-dichloroethane	*Lagodon rhomboides*	BSA	–	250-275 (O)	–	Experiments were conducted in aerated salt water. Toxicity range given as the concentrations which produced <1/2 deaths and >1/2 deaths.	Garrett (1957)
1,4-dichloro-2-nitrobenzene	Green sunfish	BSA	–	6.5 (T1A) 4.5 (T2A)	a e p	The main purpose of this experiment was to determine the repellent characteristics of certain chemicals. Experiments were conducted in a wooden trough. The toxic action of this chemical appeared to involve suffocation.	Summerfelt and Lewis (1967)
4,4-dichloro-alpha-methylbenzhydrol	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – PT (3) Ma – NT So – NT Cv – NT Gp – PT (14) Np – NT	Palmer and Maloney (1955)
2,3-dichloronaphthoquinone	Fish: *Pomoxis nigromaculatus* *Notropis antherinoides* *Hyborhynchus notatus* *Ambloplites rupestris* *Huro salmoides* Water Plants: *Ceratophyllum* *Myrophyllum* *Elodea* Invertebrates: Snails *Daphnia* Rotifers	BSA	–	(O)	e	Aerated spring water was used as the test medium. No effect was observed on fish after 2 days of exposure, even with excess solid dispersed in water. No effect was observed on higher aquatic plants and green algae. At concentrations in excess of saturation level (100 mg/l), no toxic effect was observed. At algicidal concentrations, no toxic effect was noted on any of the species studied.	Fitzgerald, et al (1952)

2,3-dichloro-napthoquinone	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – PT (7) Ma – T So – NT Cv – PT (7) Gp – T (7), PT (14) Np – T	Palmer and Maloney (1955)
2,3-dichloro-naphthoquinone	*Pimephales promelas*	BSA	–	0.15 (T4A)	a c d e f	Toxicity to 30 species of algae also presented. 2,3 DNQ was algicidal in the range 0.5 to 2.5 ppm.	Maloney and Palmer (1956)
2,5-dichloro-4-nitrophenol	*Petromyzon marinus* (larvae)	BSA	–	10 (K<1)	a	Additional data are presented.	Piavis (1962)
2,5-dichloro-4-nitrophenol (Na salt)	*Petromyzon marinus*	BSA	–	5 (K 100%)	a	Mortality occurred in approximately 24 hr. This was a study on controlling sea lamprey larvae.	Ball (1966)
	Salmo trutta	BSA	–	17 (K 10%)	a		
2,5-dichloro-4-nitrophenol (free phenol)	*Petromyzon marinus*	BSA	–	3 (K 100%)	a	Comment same as above.	Ball (1966)
	Salmo gairdnerii	BSA	–	13 (K 10%)	a		
	S. trutta	BSA	–	7 (K 10%)	a		
3',4'-dichloro-3-nitrosalicylanilide	*Salmo gairdnerii*	BSA	–	1.0 (K 3 hr)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule.	Walker, et al (1966)
	Carassius auratus			1.0 (K2) 10.0 (K 3 hr)			
Dichlorophenoxybutyric acid	*Pteronarcys* sp (nymphs)	BSA	–	15.0 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Di (p-chloro-phenyl) methyl carbinol	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – PT (7) Ma – NT So – T (3) Cv – T (3) Gp – T (3) Np – T (3)	Palmer and Maloney (1955)
Diethanol-amine	*Gambusia affinis*	BSA	–	1,550 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Diethanol-amine	Sewage microorganisms	BOD	–	(O)	–	The chemical was studied as to how low levels (ppm) may affect the BOD in domestic sewage. This compound was not toxic to sewage organisms, but responded readily to acclimated seed and contributed to the biochemical oxygen demand.	Oberton and Stack (1957)
Diethylamine	*Semotilus atromaculatus*	BSA	–	70 to 100 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
Diethylamino-hydrochloride	*Semotilus atromaculatus*	BSA	–	4,000 to 6,000 (CR)	a e	Comment same as above.	Gillette, et al (1952)
2',5'-diethyl-3,5-dinitro-benzanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	(O) (O)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule. At 10 ppm the chemical was not toxic to trout. At 10.0 ppm, the chemical was toxic to 1 out of 10 goldfish in 48 hours.	Walker, et al (1966)
Diethylene glycol	*Gambusia affinis*	BSA	–	32,000 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)

Diethyl-ethanol-amine	*Semotilus atromaculatus*	BSA	–	80 to 120 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
Diethyl nitrosoamine	*Semotilus atromaculatus*	BSA	–	900-1,100 (CR)	a e	Comment same as above.	Gillette, et al (1952)
1,3-diethyl-thiourea	*Semotilus atromaculatus*	BSA	–	100 to 300 (CR)	a e	Comment same as above.	Gillette, et al (1952)
Diglycolic acid	*Lepomis macrochirus*	BSA	–	105 (T1A)	a b e	This report is a simple and straightforward determination of a median tolerable limit for a selected group of herbicides.	Hughes and Davis (1967)
m-dihydroxy-benzene	Sewage organisms	BOD	–	(NTE)	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Di-isobutyl-amine	*Semotilus atromaculatus*	BSA	–	20 to 40 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
Di-isopropyl-amine	*Semotilus atromaculatus*	BSA	–	40 to 60 (CR)	a e	Comment same as above.	Gillette, et al (1952)
Dimethyl-amine	*Semotilus atromaculatus*	BSA	–	30 to 50 (CR)	a e	Comment same as above.	Gillette, et al (1952)
Dimethylamino-benzaldehyde	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – NT Ma – NT So – NT Cv – NT Gp – NT Np – NT	Palmer and Maloney (1955)
0,0-dimethyl dithiophosphate (47.7 percent)	*Lymnaeid* snails	BSA	–	(O)	–	Each test container, 500-ml beaker, was filled with ditch water. Less than 100% mortality occurred in concentrations of 1:100,000.	Batte, et al (1951)
4,5-dimentyl-2-mercapto-thiazole	*Daphnia magna*	BSA	–	56 (K2)	a	An attempt was made to correlate the biological action with the chemical reactivity of selected chemical substances. Results indicated a considerable correlation between the aquarium fish toxicity and antiautocatalytic potency of the chemicals in marked contrast to their toxicity on systemic administration.	Sollman (1949)

Chemical	Organism	Bioassay or Field Study$^{(1)}$	Field Location$^{(2)}$	Toxicity, Active Ingredient, ppm$^{(3)}$	Experimental Variables Controlled or Noted$^{(4)}$	Comments	Reference (Year)
2',3'-dimethyl-3-nitrosalicyl-anilide	Sea lamprey (larva) *Salmo gairdneri* (fingerling)	BSA	–	3.0 (LD_{100}) 5.0 (LD_{25})	See Applegate, et al (1957-1958)	This paper deals with the comparative toxicity of halonitrosalicylanilides to sea lamprey and fingerling rainbow trout as a function of substituent loci.	Starkey and Howell (1966)
2',4'-dimethyl-3-nitrosalicyl-anilide	Sea lamprey (larva) *Salmo gairdneri* (fingerling)	BSA	–	3.0 (LD_{100}) 7.0 (LD_{25})	See Applegate, et al (1957-1958)	Comment same as above.	Starkey and Howell (1966)
2',5'-dimethyl-3-nitrosalicyl-anilide	Sea lamprey (larva) *Salmo gairdneri* (fingerling)	BSA	–	1.0 (LD_{100}) 0.7 (LD_{25})	See Applegate, et al (1957-1958)	Comment same as above.	Starkey and Howell (1966)
2',6'-dimethyl-3-nitrosalicyl-anilide	Sea lamprey (larva) *Salmo gairdneri* (fingerling)	BSA	–	>10.0 (LD_{100}) >10.0 (LD_{25})	See Applegate, et al (1957-1958)	Comment same as above.	Starkey and Howell (1966)
Dimethyl sulphoxide	*Carassius auratus*	BSA	–	(O)	a f	At 32 ppt DMSO, five goldfish survived for 10 days without exhibiting signs of respiratory stress or symptoms of toxic reaction. In a similar concentration of acetone the median period of survival was about 90 minutes.	Ball (1966)
Dimethyl sulfoxide	*Hemigrammus erythrozonus* *Paracheinodon innesi* *Xiphophorus maculatus* *Pescilia latipinna* *Poecilia reticulata* *Brachydanio rerio* *Corydoras paleatus*	BSA	–	(O)	a c e	According to the authors, the LD_{50} concentration in 0-5 days was found to be 1.9% for *P. innesi*, *H. erythrozonus*, *P. reticulata*, *P. latipinna*, and *X. maculatus*. *B. rerio* and *C. poleatus* tolerated higher concentrations of DMSO for longer periods of time.	Rabinowitz and Myerson (1966)

Dimethyl sulfoxide	*Salmo gairdneri*	BSA	--	53,000 (T1A) 32,300 (T3A)	a i	Water quality had little effect on toxicity of DMSO but increased temperature increased the toxicity to rainbow trout.	Willford (1967)
	Salvelinus fontinales			54,500 (T1A) 36,500 (T3A)			
	S. namaycush			47,800 (T1A) 37,300 (T3A)			
	Cyprinus carpio			44,000 (T1A) 41,700 (T3A)			
	Ictalurus melas			42,500 (T1A) 36,500 (T3A)			
	I. punctatus			39,000 (T1A) 32,500 (T3A)			
	Lepomis cyanellus			65,000 (T1A) 43,000 (T2A)			
	L. macrochirus			72,000 (T1A) 33,500 (T2A)			
	Perca flavescens			65,000 (T1A) 37,000 (T2A)			
Dimethyl sulfoxide	*Oncorhynchus tshawytscha* *O. nerka* *O. kisutch* *Salmo gairdneri*	BSA	–	12 (L)	a	LD_{50} values were reported in g DMSO/kg body wt. Fish usually died within 24 hr after intraperitoneal injection.	Benville, et al (1968)
1,3-dimethyl-urea	*Semotilus atromaculatus*	BSA	–	7,000 to 15,000 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
3,5-dinitro-benzanilide	*Salmo gairdnerii*	BSA	–	(O)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule. At 10 ppm, this chemical was not toxic to trout or goldfish.	Walker, et al (1966)
	Carassius auratus			(O)			
m-dinitro-benzene (tech)	*Lymnaeid* snails	BSA	–	(O)	—	Each test container (50-ml beaker) was filled with ditch water. Less than 100% mortality occurred in concentrations of 1:100,000.	Batte, et al (1951)
m-dinitro-benzene	*Microcystis aeruginosa*	L	–	50 (K)	a	The chemical was tested on a 5-day algae culture, 1×10^6 to 2×10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
3,5-dinitro-2',3'-benzoxylidide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	(O) (O)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule. At 10.0 ppm, the chemical was toxic to 1 out of 10 trout in 48 hours. At 10 ppm the chemical was not toxic to goldfish.	Walker, et al (1966)
3,5-dinitro-o-benzotoluidide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	10.1 (K2) (O)	a	Comment same as above except at 10.0 ppm, the chemical was toxic to 8 out of 10 goldfish at 48 hours.	Walker, et al (1966)
Dinitro-o-sec-butylphenol (tech)	*Lymnaeid* snails	BSA	–	(O)	–	Comment same as above except 100% mortality occurred at 1:200,000 and greater	Batte, et al (1951)
Dinitro-o-sec-butylphenol	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cy)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – NT Ma – NT So – NT Cv – NT Gp – NT Np – NT	Palmer and Maloney (1955)
2,6-dinitro-4-chlorophenol (tech)	*Lymnaeid* snails	BSA	–	(O)	–	Each test container (500-ml beaker) was filled with ditch water. Less than 100% mortality occurred in concentrations of 1:100,000.	Batte, et al (1951)
Dinitrocresol (tech)	*Pteronarcys californica* (naiads)	BSA	–	0.00032 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
3,5-dinitro-o-cresol (tech)	*Lymnaeid* snails	BSA	–	(O)	–	Each test container (500-ml beaker) was filled with ditch water. Less than 100% mortality occurred in concentrations of 1:100,000.	Batte, et al (1951)
4,6-dinitro-o-cresol acetate (tech)	*Lymnaeid* snails	BSA	–	(O)	–	Comment same as above.	Batte, et al (1951)

4,6-dinitro-o-cresol methyl ether (tech)	*Lymnaeid* snails	BSA	–	(O)	–	Comment same as above.	Batte, et al (1951)
Dinitro-o-cyclohexylphenol (38 percent)	*Lymnaeid* snails	BSA	–	(O)	–	Comment same as above except 100% mortality occurred in concentrations of 1:400,000 and greater.	Batte, et al (1951)
Dinitro-o-cyclohexylphenol, dicyclohexyiamine salt (tech)	*Lymnaeid* snails	BSA	–	(O)	–	Comment same as above except 100% mortality occurred in concentrations of 1:200,000 and greater.	Batte, et al (1951)
Dinitro-o-cyclohexylphenol	*Lymnaeid* snails	BSA	–	1.0 (K1)	–	Each test container (500-ml beaker) was filled with ditch water.	Batte, et al (1951)
Dinitro-o-cyclohexylphenol, dicyclohexylamine salt (20 percent)	*Lymnaeid* snails	BSA	–	(O)	–	Comment same as above except 100% mortality occurred in concentrations of 1:400,000 and greater.	Batte, et al (1951)
2,4-dinitrophenol	Sewage organisms	BOD	–	100 (TC_{50})	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
2,4-dinitrophenol (tech)	*Lymnaeid* snails	BSA	–	(O)	–	Each test container (500-ml beaker) was filled with ditch water. Less than 100% mortality occurred in concentrations of 1:100,000.	Batte, et al (1951)
2,4-dinitrophenolhydrazine (tech)	*Lymnaeid* snails	BSA	–	(O)	–	Comment same as above.	Batte, et al (1951)
2,4-dinitrophenol, sodium salt (tech)	*Lymnaeid* snails	BSA	–	(O)	–	Comment same as above.	Batte, et al (1951)
2,4-dinitrophenylhydrazine	*Microcystis aeruginosa*	L	–	100 (K)	a, etc.	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
2,4-dinitrophenylhydrazine	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – NT Ma – NT So – NT PT (7) Cv – NT Gp – NT Np – NT	Palmer and Maloney (1955)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
2',3-dinitro-m-salicylanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	1.0 (K2) 10.0 (K 3 hr) (O)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule. At 10.0 ppm, the chemical was not toxic to goldfish.	Walker, et al (1966)
2',3-dinitro-p-salicylotoluidide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	1.0 (K2) 10.0 (K 3 hr) 10.0 (K 2)	a	Comment same as above except data cited.	Walker, et al (1966)
3,5-dinitro-o-salicylotoluidide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	10.0 (K 3 hr) (O)	a	Comment same as above except that at 10.0 ppm, the chemical was toxic to 9 out of 10 goldfish at 48 hr.	Walker, et al (1966)
2,4-dinitro-thymol (tech)	*Lymnaeid* snails	BSA	–	(O)	–	Each test container (500-ml beaker) was filled with ditch water. 100% mortality occurred in concentrations of 1:400,000 and greater.	Batte, et al (1951)
2,4-dinitro-toluene (tech)	*Lymnaeid* snails	BSA	–	(O)	–	Comment same as above except less than 100% mortality occurred in concentrations of 1:100,000.	Batte, et al (1951)
Di-n-propylamine	*Semotilus atromaculatus*	BSA	–	20 to 60 (CR)	a e	Test water was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
Disodium copper salt of ethylene diamine-tetra acetic acid	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – NT Ma – PT (14) So – NT Cv – NT Gp – NT NP – NT	Palmer and Maloney (1955)

Disodium ethylene bisdithio-carbamate	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Comment same as above except that: Cl – NT Ma – PT (14) So – NT Cv – T (3) Gp – T (3) Np – T (3)	Palmer and Maloney (1955)
Disodium octoborate tetrahydrate	*Salmo gairdnerii*	BSA	–	4200 (T1A) 2750 (T2A)	a e	Most of the weed-killer formulations in this study consisted of more than one substance, i.e., oils, emulsifiers, stabilizers, and other adjuvants.	Alabaster (1956)
Dodecylaceta-mido-dimethyl benzyl ammonium chloride	*Cyclindrospermum licheniforme (Cl)* *Gleocapsa sp (GP)* *Scenodesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – PT (7) G – T (3), PT (14) So – T Cv – T Gp – T Np – T	Palmer and Maloney (1955)
Ethanol	*Lesbistes reticulatus* *Carassius auratus*	BSA	–	(O)	a c	The uptake of ethanol from buffered solution by guppies has been studied. There was an apparent increase in the rate of absorption with increasing pH. Experiments with goldfish failed to show an increase in absorption rate as the pH was increased.	Hayton and Hall (1968)
Ethyl alcohol	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, possible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compares this work with earlier work, and lists an extensive bibliography. In a concentration of 16 cc per liter, fish survived 98 minutes.	Powers (1918)
Ethyl alcohol	*Daphnia magna*	BSA	–	18,400 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Ethyl alcohol	*Pygosteus pungitius*	BCF	–	(O)	a	A concentration of 4 percent ethyl alcohol immediately intoxicated the fish, which recovered when placed in fresh water. A 1 percent solution caused the fish to exhibit an avoidance reaction.	Jones (1949)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Ethyl alcohol	*Semotilus atromaculatus*	BSA	–	7,000 to 9,000 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hrs. and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
Ethyl benzene	*Pimephales promelas*	BSA	–	40 (T4A)	a c d e f	Most fish survived at test concentrations of about one half, or slightly more, of the TL_m value. No attempt was made to estimate 100 percent survival.	Pickering and Henderson (1966)
	Lepomis macrochirus			29 (T4A)			
	Carassius auratus			73 (T4A)			
	Lebistes reticulatus			78 (T4A)			
Ethyldiethanolamine	*Semotilus atromaculatus*	BSA	–	160 to 200 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
Ethylene diamine	*Semotilus atromaculatus*	BSA	–	30 to 60 (CR)	a e	Comment same as above.	Gillette, et al (1952)
Ethylene thiourea	*Semotilus atromaculatus*	BSA	–	6,000 to 8,000 (CR)	a e	Comment same as above.	Gillette, et al (1952)
2,ethyl-1,3-hexanediol	Channel catfish (fingerlings)	BSA	–	624 (K 25 hr A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
1-(2-ethyl-hexyl)-2-undecyl-1,4,5,6-tetrahydro-pyrimidine	*Microcystis aeruginosa*	L	–	2.0 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
Ethylmercuric chloride	*Artemia salina*	BSA	–	24.0 (O)	a c	All tests were conducted in seawater.	Corner and Sparrow (1956)
	Acartia clausi			2.0 (O)		Toxicity values reported are relative to that of mercuric chloride expressed as unity.	
	Elminius modestus			4.4 (O)		Mechanism of action is discussed, as well as synergistic action of two poisons administered simultaneously.	

2'-ethyl-3-nitro-salicylanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	(O)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule. No affect occurred for rainbow trout or goldfish at 0.1 and 1.0 ppm.	Walker, et al (1966)
O-ethyl-s-pentachlorophenyl thiocarbamate	*Petromyzon marinus* (larvae)	BSA	–	10 (K<1)	a	Additional data are presented.	Piavis (1962)
Ferric chloride	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, possible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compared this work with earlier work, and lists an extensive bibliography. In a concentration of 0.284N, fish survived 29 minutes; in a concentration of 0.0000166N, they survived 1200 minutes.	Powers (1918)
Ferric chloride	*Daphnia magna*	BSA	–	130 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Ferric chloride	*Daphnia magna*	BSA	–	<18 (S)	a	Lake Erie water was used as diluent. Toxicity given as threshold concentration producing immobilization for exposure periods of 64 hr.	Anderson (1944)
Ferric chloride	*Gambusia affinis*	BSA	–	74 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Ferric chloride	*Biomorpholaria alexandrina* *Bulinus truncatus*	BSA	–	200 (K1) 200 (K1)	a	The degree of tolerance for vector snails of bilharziasis to various chemicals is somewhat dependent upon temperature. The temperature at which (K1) occurred was 26 C.	Gohar and El-Gindy (1961)
Ferric chloride	*Daphnia magna*	BSA	–	36 (T1A) 21 (T2A) 15 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Ferric sulfate	*Gambusia affinis*	BSA	–	133 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Ferrocyanide complex Sodium cyanide (482 ppm CN^-) and Ferrous sulfate (193 ppm Fe^{++})	*Pimephales promelas*	BSA	–	10 (K <48 hr)	a c	Synthetic soft water was used. Toxicity data given as number of test fish surviving after exposure at 24, 48, and 96 hr.	Doudoroff, et al (1956)
Ferrous chloride	*Daphnia magna*	BSA	–	<38 (S)	a	Lake Erie water was used as diluent. Toxicity given as threshold concentration producing immobilization for exposure periods of 64 hr.	Anderson (1948)
Ferrous disodium versenate	Channel catfish (fingerlings)	BSA	–	>500 (K 25 hr A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Ferrous oxide	*Gambusia affinis*	BSA	–	10,000 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Ferrous sulfate	*Daphnia magna*	BSA	–	<152 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Ferrous sulfate	*Micropterus salmoides* *Lepomis machrochirus* Goldfish	BSA	–	100 (O) 100 (O) 100 (O)	a c f p i	The disposal of cannery wastes frequently involves the use of chemicals for treatment purposes. Ferrous sulphate, alum, and lime are used in chemical coagulation; sodium carbonate for acidity control in biological filters; and sodium nitrate in lagoons for odor control. Lye (sodium hydroxide) peeling of certain fruits and vegetables is not uncommon. These chemicals, in whole or part, are discharged in most cases to a stream. The concentrations listed permitted large mouth bass to survive 2.5 to 3.5 days, and goldfish to survive indefinitely.	Sanborn (1945)
Ferrous sulfate	Sewage organisms	BOD	–	(NTE)	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Ferrous sulphate	*Biomorpholaria alexandrina* *Bulinus truncatus*	BSA	–	900 (K1) 900 (K1)	a	The degree of tolerance for vector snails of bilharziasis to various chemicals is somewhat dependent upon temperature. The temperature at which (K1) occurred was 27 C.	Gohar and El-Gindy (1961)

Ferrous sulfide	*Gambusia affinis*	BSA	–	10,000 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Ferrous sulfite	*Gambusia affinis*	BSA	–	350 (T2A)	a c d e g	Comment same as above.	Wallen, et al (1957)
Fluoride	*Salmo gairdnerii*	BSA	–	(H) 250 (K21) (H) 150 (90% K21) (H) 100 (NTE 21) (S) 253 (K21) (S) 113 (K21) (S) 75 (NTE 21)	a d	Aerated lake and well water were used as diluents. Toxicity data are given as percentage killed at various concentrations of fluoride in both hard (320 ppm) and soft water (45 ppm). Threshold for 50% mortality was 8.5 ppm F in 504 hr (21 days).	Herbert and Shurben (1964)
Fluoride	*Chlorella pyrenoidosa*	L	–	(O)	–	Fluoride caused growth inhibition in cultures of *Chlorella pyrenoidosa*. This antimetabolite had its greatest effect at concentrations greater than 10^{-3} M. No proportionality could be established between the concentrations of fluoride and the percentages of inhibition occurring at these concentrations.	Smith and Woodson (1965)
2'-fluoro-3',5'-dinitrobenzanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	10 (K2) 10 (K2)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule.	Walker, et al (1966)
3'-fluoro-5-nitrosalicylanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	1.0 (K2) 10.0 (K 3 hr) 10.0 (K2)	a	Comment same as above.	Walker, et al (1966)
3'-fluoro-3-nitrosalicylanilide	Sea lamprey (larva) *Salmo gairdneri* (fingerling)	BSA	–	0.5 (K) (O)	See Applegate, et al (1957-1958)	This paper deals with the comparative toxicity of halonitrosalicylanilides to sea lamprey and fingerling rainbow trout as a function of substituent loci. 0.9 ppm killed 25%.	Starkey and Howell (1966)
2'-fluoro-3-nitrosalicylanilide	Sea lamprey (larva) *Salmo gairdneri* (fingerling)	BSA	–	1.0 K	See Applegate, et al (1957-1958)	Comment same as above. 3.0 ppm killed 25%.	Starkey and Howell (1966)
4'-fluoro-3-nitrosalicylanilide	Sea lamprey (larva) *Salmo gairdneri* (fingerling)	BSA	–	1.0 (K)	See Applegate, et al (1957-1958)	Comment same as above. 3.0 ppm killed 25%.	Starkey and Howell (1966)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
4-fluoro-5-nitrosalicylanilide	Sea lamprey (larva)	BSA	–	3.0 (K)	See Applegate, et al (1957-1958)	This paper deals with the comparative toxicity of halonitrosalicylanilides to sea lamprey and fingerling rainbow trout as a function of substituent loci.	Starkey and Howell (1966)
Fluosilicic acid	Sewage organisms	BOD	–	2.6 (O)	–	Various metal salts were studied in relation to how they affected the BOD of both raw and treated sewage as well as how they affected the processing of sewage in the treatment plant. BOD was used as the parameter to measure the effect of the chemical. The chemical concentration cited is the ppm required to reduce the BOD values by 50%. This chemical was tested in an unbuffered system.	Sheets (1957)
Formaldehyde (40% soln)	*Pygosteus pungitius*	BCF	–	(O)	a	Concentrations of 0.1 to 0.4 percent (v/v) caused the fish to show a negative reaction and appear to be irritated.	Jones (1947)
Formaldehyde	Sewage organisms	BOD	–	740 (TC_{50})	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Formaldehyde	*Daphnia magna*	BSA	–	100 1000 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Formaldehyde	*Salmo gairdneri*	BSA	–	168 (T2A)	a f	Variance and the 95-percent confidence interval (C.I.) were also determined.	Willford (1966)
	Salmo trutta			185 (T2A)			
	Salvelinus fontinalis			157 (T2A)			
	Salvelinus namaycush			167 (T2A)			
	Ictalurus punctatus			96 (T2A)			
	Lepomis macrochirus			140 (T2A)			
Formalin	*Ictalurus punctatus*	BSA	–	126 (K2A) 87 (T2A)	a c f i	The experiment was conducted at 77 C.	Clemens and Sneed (1958)
Formalin (by volume)	Channel catfish (fingerlings)	BSA	–	87 (K 25 hr A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Formalin	Tadpoles Various fish	FL	Ill.	25-30 (K)	a c	After preliminary tests in aquaria, nine pond treatments were made in six different ponds ranging in size from 0.03 to 0.5 acre. Formalin treatments caused oxygen depletion, which, in turn, resulted in a fish kill. The ponds were treated with formalin at 25 to 30 ppm. The authors recommend that when fish are present, not more than 30 ppm should be used to kill tadpoles in ponds.	Helms (1967)

Formalin	*Rana catesbeiana*	BSA	–	80 (K), 53 (L1)	a c	Data are reported as LD_{50}, although TL_m or LC_{50} might have been more appropriate. The (K) represents minimum concentration for 100 percent kill.	Helms (1967)
	R. pipiens			30 (K), 22 (L1)			
	Bufo sp			50 (K), 45 (L3)			
	Notemigonus crysoleucas			87 (L1), 67 (L2), 62 (L3)			
	Cyprinus carpio			70 (L3)			
	Ictalurus melas			70+ (L1), 49 (L2), 45 (L3)			
	Largemouth bass			100 (L3)			
	Lepomis macrochirus			100+ (L2), 80 (L3)			
	L. cyanellus			90 (L3)			
	Tilapia sp			100 (L3)			
Formic acid	Sewage organisms	BOD	–	550 (TC_{50})	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Formic acid	*Lepomis macrochirus*	BSA	–	175 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Furfural	*Gambusia affinis*	BSA	–	24 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Glutaric acid	*Lepomis macrochirus*	BSA	–	330 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Heptane	*Gambusia affinis*	BSA	–	4,924 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Hexamethylene-tetramine	Sewage organisms	BOD	–	(NTE)	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Hydrochloric acid	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, possible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compares this work with earlier work, and lists an extensive bibliography. In 0.0000313N solution, fish survived 1200 minutes.	Powers (1918)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Hydrochloric acid	*Daphnia magna*	BSA	–	62 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wates as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Hydrochloric acid	*Semotilus atromaculatus*	BSA	–	60 to 80 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
Hydrochloric acid	*Lepomis macrochirus*	BCFA	–	(O)	a c e f	Test water was composed of distilled water with CP grade chemicals and was aerated throughout the 96-hour exposure period. Toxicity was dependent upon pH. At pH 3.90 to 4.05, 10 percent of the fish died after 2 days. At pH 3.65, 50 percent survived after 3 days.	Cairns and Scheier (1955)
Hydrochloric acid	*Gambusia affinis*	BSA	–	282 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Hydrochloric acid	*Lepomis macrochirus*	BSA	–	3.5 (pH, T4A)	a c d e i	A "control" was prepared by adding required chemicals to distilled water, and this was constantly aerated. Data reported are for larger fish, app 14.24 cm in length. Data for smaller fish are also in the report.	Cairns and Scheier (1959)
Hydrocyanic acid	*Lagodon rhomboides*	BSA	–	0.069 (T1A)	a	Aerated sea water was used.	Daugherty and Garrett (1951)
Hydrogen cyanide	*Lagodon rhomboides*	BSA	–	0.069 (T1A)	–	Experiments were conducted in aerated salt water.	Garrett (1957)
Hydrogen cyanide	Fish	BSA	–	7.7 x 10^{-6} M (K)	a c	Avoidance behavior of test fish to toxic chemicals is given. Toxicity is given as the lowest lethal concentration (molar). Ratios of avoidance and lowest lethal concentration are presented and discussed.	Ishio (1965)
HCN	*Lepomis macrochirus* (juveniles)	BSA	–	0.16 (T3A)	a c d f p	The solutions were prepared with NaCN, but the data given are calculated as free HCN.	Doudoroff, et al (1966)
Hydrogen cyanide	*Salmo gairdnerii*	BSA	–	0.07 (T2A)	a c d e f o	The concentration killing a half batch of fish in 2 days provides a reasonable estimate of the threshold concentration. The toxicity of cyanide is related to the concentration of molecular hydrogen cyanide, and not of the cyanide ion (CN^-). The lower the pH value the greater the proportion of molecular HCN.	Brown (1968)

H ion	Fish	BSA	–	1.0×10^{-5} M (K)	a c	Avoidance behavior of test fish to toxic chemicals is given. Toxicity is given as the lowest lethal concentration (molar). Ratios of avoidance and lowest lethal concentration are presented and discussed.	Ishio (1965)
Hydrogen sulphide	*Oncorhyncus tshawytscha* *Oncorhyncus kisutch* *Salmo clarkii clarkii*	BSA	–	1.0 (K5) 1.2 (K5) 1.0 (K5)	a d e	This chemical is one of a number that may be found in Kraft mill waste effluents. Data are expressed as minimum lethal concentration for 5 days.	Haydu, et al (1952)
Hydrogen sulfide	*Bullia* (Gastropoda)	BSA	–	(O)	–	No quantitative data are reported. H_2S was bubbled through sea water. When animals of this species were exposed to the H_2S solution more than half an hour, they were killed. Animals removed after 15 minutes, then placed in fresh aerated sea water, recovered.	Brown (1964)
Hydrogen sulfide (undissociated)	Fish	BSA	–	1.9×10^{-5} M (K)	a c	Avoidance behavior of test fish to toxic chemicals is given. Toxicity is given as the lowest lethal concentration (molar). Ratios of avoidance and lowest lethal concentration are presented and discussed.	Ishio (1965)
Hydrogen sulfide	*Ictalurus punctatus*	FL	Texas	–	a c g	One hundred cat fish were placed in a pen in one lake and in less than 48 hours, all the test fish fry were dead. Tests showed that total hydrogen sulfide to be 0.96 ppm and a pH of less than 6.0. This gave an unionized H_2S concentration of at least 0.797 ppm, which was lethal to the catfish. Based on the results of extensive tests, it was evident that the production of unionized H_2S was seasonal, and often very erratic.	Bonn and Follis (1967)
Hydrogen sulfide	*Ictalurus punctatus* *Lepomis macrochirus*	BSA	–	(O)	a c	The quantity of total sulfides necessary to produce a TL_m of the test catfish varied from 1.82 to approximately 7.0 ppm, depending upon the pH of the water. Most of the catfish fry died in approximately 10 minutes at the concentration range given above. At a pH of 7.0 the TL_m of unionized hydrogen sulfide was found to be 1.0 ppm for fingerling channel catfish, 1.3 for advanced fingerlings and 1.4 for adult catfish. The fingerlings died in approximately 20 minutes while the TL_m for advanced fingerlings and adults was attained after about 45 minutes. No TL_m was reached for bluegill in the fingerling tests.	Bonn and Follis (1967)
Hydroquinone	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1×10^6 to 2×10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
Hydroquinone	*Daphnia magna*	BSA	–	0.287 (K2)	a	An attempt was made to correlate the biological action with the chemical reactivity of selected chemical substances. Results indicated a considerable correlation between the aquarium fish toxicity and antiautocatalytic potency of the chemicals in marked contrast to their toxicity on systemic administration.	Sollman (1949)
Hydroquinone diacetate	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1×10^6 to 2×10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Hydroquinone monobenzyl ether	*Daphnia magna*	BSA	–	2.5 (K2)	a	An attempt was made to correlate the biological action with the chemical reactivity of selected chemical substances. Results indicated a considerable correlation between the aquarium fish toxicity and antiautocatalytic potency of the chemicals in marked contrast to their toxicity on systemic administration.	Sollman (1949)
Hydroquinone monomethyl ether	*Daphnia magna*	BSA	–	200 (K2)	a	Comment same as above.	Sollman (1949)
Hydroxyl ion	Fish	BSA	–	1.0×10^{-5} M (K)	a c	Avoidance behavior of test fish to toxic chemicals is given. Toxicity is given as the lowest lethal concentration (molar). Ratios of avoidance and lowest lethal concentration are presented and discussed.	Ishio (1965)
Hydroxyl ion	*Moroco steindachnerii*	L	–	11.23 to 9.74 (O)		The values given are the pH range avoided by the fish.	Ishio (1965)
	Pungtungia herzi			10.62 to 9.16 (O)			
	Acheilognathous limbata			10.12 to 9.03 (O)			
	Cyprinus carpio			10.13 to 8.62 (O)			
	Zaccho platypus			10.12 to 8.62 (O)			
	Sarcocheilichthys variegratus			9.63 to 8.71 (O)			
	Lebistes reticulatus			9.38 to 8.44 (O)			
	Carassius auratus (wild)			10.38 to 8.24 (O)			
	Carassius auratus			10.25 to 7.38 (O)			
	Gnathepogon gracilis			10.38 to 7.40 (O)			
	Pimephalus promelas			9.56 to 9.05 (O)			
	Lepomis macrochirus			9.62 to 8.76 (O)			
Hydroxyl-amine-HCl	*Microcystis aeruginosa*	L	–	50 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1×10^6 to 2×10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
Hydroxyl-ammonium benzoate	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	Comment same as above.	Fitzgerald, et al (1952)
Hydroxyl-ammonium chloride	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	Comment same as above.	Fitzgerald, et al (1952)

Hydroxyl-ammonium phosphate	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	Comment same as above.	Fitzgerald, et al (1952)
Hydroxyl-ammonium sulfate	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	Comment same as above.	Fitzgerald, et al (1952)
2'-hydroxy-phenazine-1-carboxylic acid	*Microcystis aeruginosa* *Anabaena flos-aquae* *Notemogonous crysoleucas*	L L	–	0.1 (O) 1.0 (O)	–	Concentrations noted are for complete inhibition of *M. aeruginosa* and *A. flos-aquae*. No harmful effects to *N. crysoleucas* were noted at the concentrations evaluated.	Toohey, et al (1965)
o-hydroxybenzoic acid	*Carassius auratus*	BSA	–	0.254 (K)	a	Goldfish weighed between 2 and 4 g. Temperature was maintained at 27.0 ± 0.2 C.	Gersdorff (1943)
p-hydroxybenzoic acid	*Carassius auratus*	BSA	–	0.0230 (K)	a	Comment same as above.	Gersdorff (1943)
m-hydroxybenzoic acid	*Carassius auratus*	BSA	–	0.0363 (K)	a	Comment same as above.	Gersdorff (1943)
p-hydroxyphenyl-glycine	*Daphnia magna*	BSA	–	20 (K2)	a	An attempt was made to correlate the biological action with the chemical reactivity of selected chemical substances. Results indicated a considerable correlation between the aquarium fish toxicity and antiautocatalytic potency of the chemicals in marked contrast to their toxicity on systemic administration.	Sollman (1949)
8-hydroxy-quinoline	*Microcystis aeruginosa*	L	–	100 (K)	a	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
Imidazoline	*Microcystis aeruginosa*	L	–	2.0 (K)	a, etc	Comment same as above.	Fitzgerald, et al (1952)
Iodoacetic acid	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – PT (7) Ma – T (3) So – T (3) Cv – NT Gp – PT (14) Np – NT	Palmer and Maloney (1955)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
4'-iodo-3,5-dinitrobenzanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	(O) (O)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule. Precipitation occurred at 10 ppm. At 10 ppm the chemical was not toxic to trout or goldfish.	Walker, et al (1966)
2'-iodo-3-nitrosalicylanilide	Sea lamprey (larva) *Salmo gairdneri* (fingerling)	BSA	–	1.0 (K) (O)	See Applegate, et al (1957-1958)	This paper deals with the comparative toxicity of halonitrosalicylanilides to sea lamprey and fingerling rainbow trout as a function of substituent loci.	Starkey and Howell (1966)
2'-iodo-3-nitrosalicylanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	10.0 (K 3 hr) 1.0 (K2 3 hr)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule.	Walker, et al (1966)
3'-iodo-3-nitrosalicylanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	1.0 (K 3 hr) 1.0 (K2) 10.0 (K 3 hr)	a	Comment same as above.	Walker, et al (1966)
3'-iodo-3-nitrosalicylanilide	Sea lamprey (larva) *Salmo gairdneri* (fingerling)	BSA	–	0.3 (K) (O)	See Applegate, et al (1957-1958)	This paper deals with the comparative toxicity of halonitrosalicylanilides to sea lamprey and fingerling rainbow trout as a function of substituent loci.	Starkey and Howell (1966)
4'-iodi-nitrosalicylanilide	*Ictalurus nebulosus*	BSA	–	0.005 (K) 0.0025 (SB) at 47 and 71 F	a c g	The chemical was dissolved in dimethyl sulfoxide for testing. Non-aerated, turbid and non-turbid test waters at 47 and 71 F were used. Lodging of the fish in sediment increased survival.	Loeb and Starkey (1966)

4'-iodo-3-nitrosalicylanilide	Sea lamprey (larva) *Salmo gairdneri* (fingerling)	BSA	–	0.3 (K) (O)	See Applegate, et al (1957-1958)	This paper deals with the comparative toxicity of halonitrosalicylanilides to sea lamprey and fingerling rainbow trout as a function of substituent loci. 0.7 ppm killed 25%.	Starkey and Howell (1966)
4'-iodo-3-nitrosalicylanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	1.0 (K 3 hr) 1.0 (K 3 hr)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule.	Walker, et al (1966)
4'-iodo-5-nitrosalicylanilide	*Salmo gairdnerii*	BSA	–	1.0 (K2) 10.0 (K 3 hr)	a	Comment same as above.	Walker, et al (1966)
4'-iodo-5-nitrosalicylanilide	Sea lamprey (larva) *Salmo gairdneri* (fingerling)	BSA	–	0.5 (K) (O)	See Applegate, et al (1957-1958)	This paper deals with the comparative toxicity of halonitrosalicylanilides to sea lamprey and fingerling rainbow trout as a function of substituent loci. 1.0 ppm killed 25%.	Starkey and Howell (1966)
m-iodophenol	*Carassius auratus*	BSA	–	51.7 to 155.0 (K 8 hr) 38.8 (O) 10.3 (O)	a	Temperature in test containers was maintained at 27 ± 0.2 C. Goldfish tested weighed between 2 and 4 g. m-iodophenol, 38.8 ppm, killed 75% of the fish in 8 hr; 10.3 ppm killed 33% in 8 hr.	Gersdorff and Smith (1940)
o-iodophenol	*Carassius auratus*	BSA	–	45.8 to 91.6 (K 8 hr) 36.6 (O) 26.2 (O)	a	Comment same as above except that o-iodophenol, 36.6 ppm, killed 83% of the fish in 8 hr; 26.2 ppm killed 8% in 8 hr.	Gersdorff and Smith (1940)
p-iodophenol	*Carassius auratus*	BSA	–	12.5 to 100 (K 8 hr) 11.8 (O) 10.0 (O) 7.5 (O)	a	Comment same as above except that p-iodophenol, 11.8 ppm, killed 92% of the fish in 8 hr; 10.0 ppm killed 77% in 8 hr; and 7.5 ppm killed 46% in 8 hr.	Gersdorff and Smith (1940)
Iron	*Daphnia magna*	L	–	100 (K)	a c e	It is assumed in this experiment that the cations considered are toxic because they combine with an essential sulfhydryl group attached to a key enzyme. This treatment indicates that the metals which form the most insoluble sulfides are the most toxic. The log of the concentration of the metal ion is plotted against the log of the solubility product constant of the metal sulfide – a treatment that does not lend itself to tabulation. The cation toxicity cited is only an approximate concentration interpolated from a graph. Time of death was not specified.	Shaw and Grushkin (1967)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Iso-amyl alcohol	*Daphnia magna*	BSA	–	881 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Isoamyl alcohols, mixed primary	*Semotilus atromaculatus*	BSA	–	400 to 600 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
Isobornyl thiocyanoacetate	Green sunfish Largemouth bass Black bullhead Golden shiner Mosquito fish Tadpoles Crayfish Bluegill Channel catfish Redear sunfish White crappie	FL	Ill.	(O)	a	Ponds were treated with concentrations of 0.7, 0.8, and 1.5 ppm of the chemical. The ponds were drained or poisoned after the removal of isobornyl thiocyanoacetate-affected fish were removed. This was done to determine the numbers of each species that had survived. Water temperature in the ponds ranged from 50 to 87 F. Pond sizes ranged from 0.1 to 455 acres. Results were quite similar to the results obtained in bioassay studies. Centrarchids were selectively killed in the presence of ictalurids and cyprinids.	Lewis (1968)
Isobornyl thiocyanoacetate		BSA	–		a	Twenty liter-glass aquaria were employed for the experiments. Temperature was maintained at 20 to 23 C. Results are recorded as 24-hr lethal minimum dose of the chemical.	Lewis (1968)
	Green sunfish			0.6 (O)		24-hr lethal minimum dose at 20 to 23 C.	
	Rainbow trout			<0.7 (O)		24-hr lethal minimum dose at 11 C.	
	Golden shiner			1.5 (O)		24-hr lethal minimum dose at 20 to 23 C.	
	Channel catfish			1.5 (O)		24-hr lethal minimum dose at 20 to 23 C.	
	Black bullhead			>1.5 (O)		24-hr lethal minimum dose at 20 to 23 C.	
	Bluegill			0.4 (O)		24-hr lethal minimum dose at 20 to 23 C.	

Isobutyl alcohol	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, possible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compares this work with earlier work, and lists an extensive bibliography. In a concentration of 5.85 cc per liter, fish survived 61 minutes.	Powers (1918)
Isoprene	*Pimephales promelas*	BSA	–	75 (T4A)	a c d e f	Most fish survived at test concentrations of about one half, or slightly more, of the TL_m value. No attempt was made to estimate 100 percent survival.	Pickering and Henderson (1966)
	Lepomis macrochirus			39 (T4A)			
	Carassius auratus			180 (T4A)			
	Lebistes reticulatus			140 (T4A)			
p-isopropoxy diphenyl	*Daphnia magna*	BSA	–	5.7 (K2)	a	An attempt was made to correlate the biological action with the chemical reactivity of selected chemical substances. Results indicated a considerable correlation between the aquarium fish toxicity and antiautocatalytic potency of the chemicals in marked contrast to their toxicity on systemic administration.	Sollman (1949)
p-isopropoxy diphenylamine	*Daphnia magna*	BSA	–	5.7 (K2)	a	Comment same as above.	Sollman (1949)
Isopropyl alcohol	*Semotilus atromaculatus*	BSA	–	900 to 1,100 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
1-isopropyl-2-(8,11-heptadecadienyl)-4,4-dimethyl-2-imidazoline	*Microcystis aeruginosa*	L	–	2.0 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1×10^6 to 2×10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
1-isopropyl-2-(S-heptadecenyl)-4,4-dimethyl-2-imidazoline	*Microcystis aeruginosa*	L	–	1.0 (K)	a, etc	Comment same as above.	Fitzgerald, et al (1952)
1-isopropyl-2-nonyl-4,4-dimethyl-2-imidazoline	*Microcystis aeruginosa*	L	–	2.0 (K)	a	Comment same as above.	Fitzgerald, et al (1952)
1-isopropyl-2-undecyl-4,4-dimethyl-2-imidazoline	*Microcystis aeruginosa*	L	–	2.0 (K)	a, etc	Comment same as above.	Fitzgerald, et al (1952)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Lactic acid	*Daphnia magna*	BSA	–	243 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Lactonitrile	*Lagadon rhomboides*	BSA	–	0.215 (T1A)	a	Aerated seawater was used.	Daugherty and Garrett (1951)
Lactonitrile	*Lagadon rhomeboides*	BSA	–	0.215 (T1A)	–	Experiments were conducted in aerated salt water.	Garrett (1957)
Lactonitrile	*Lepomis auritus* *Lepomis macrochirus* *Pomoxis annularis*	BSA & CF	–	0.06-0.1 (100% KCF) 0.03-0.1 (100% KS) 0.055-0.07 (100% KF) 0.075 (100% KS) 0.065-0.07 (100% KS)	a	Additional data are presented for less than 24 hr.	Renn (1955)
Lactonitrile	*Pimephales promelas* *Lepomis macrochirus* *Lebistes reticulatus* *Pimephalus promelas*	BSA	–	(S) 0.90 (T4A) (S) 0.90 (T4A) (S) 1.37 (T4A) (H) 0.90 (T4A)	c d e f	(H) Value for hard water. (S) Value for soft water. The chemical did not change the flavor of the cooked bluegill.	Henderson, et al (1960)
Laurylisoquino-linium bromide	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – T (3) PT (7) Ma – PT (14) So – T (3) Cv – PT (7) Gp – PT (7) Np – PT (7)	Palmer and Maloney (1955)

Lead	*Lebistes reticulatus*	BSA	–	1.0 (K)	a c e	It is assumed in this experiment that the cations considered are toxic because they combine with an essential sulfhydryl group attached to a key enzyme. This treatment indicates that the metals which form the most insoluble sulfides are the most toxic. The log of the concentration of the metal ion is plotted against the log of the solubility product constant of the metal sulfide – a treatment that does not lend itself to tabulation. The cation toxicity cited is only an approximate concentration interpolated from a graph. Time of death was not specified.	Shaw and Grushkin (1967)
	Bufo valliceps (tadpoles)			100.0 (K)			
	Daphnia magna			10.0 (K)			
Lead	*Gasterosteus aculeatus*	BSA	–	0.1 (O)	a c e	This is a discussion of a bioassay method using stickleback fish and spectrophotometric determinations of the chemicals evaluated. The number listed is said to be the "toxic limit" for the fish.	Hawksley (1967)
Lead acetate	*Pimephales promelas* *Lepomis macrochirus*	BSA	–	(S) 7.48 (T4A)	c d e f	(S) Soft water. Values are expressed as mg/l of lead.	Pickering and Henderson (1965)
Lead chloride	*Daphnia magna*	BSA	–	1.25 (S)	a	Lake Erie water was used as diluent. Toxicity given as threshold concentration producing immobilization for exposure periods of 64 hr.	Anderson (1948)
Lead chloride	*Pimephales promelas*	BSA	–	(H) >75 (T4A) (S) 2.4 (T4A)	a c d f	Both hard (H) and soft (S) water were used.	Tarzwell and Henderson (1960)
Lead chloride	*Pimephales promelas*	BSA	–	(S) 5.58 (T4A) (H) 482.0 (T4A)	c d e f	(S) Soft water. (H) Hard water. Values are expressed as mg/l of metal.	Pickering and Henderson (1965)
	Lepomis macrochirus			(S) 23.8 (T4A) (H) 442.0 (T4A)			
	Carassius auratus			(S) 31.5 (T4A)			
	Lebistes reticulatus			(S) 20.6 (T4A)			
Lead nitrate	*Gasterosteus aculeatus*	BSA	–	0.3 (TL4-3/4A)	a c	Death of the fish resulted from an interaction between the metallic ion and the mucus secreted by the gills. Coagulated mucus formed on the gill membranes and impaired respiration to such a degree that the fish asphyxiated. The addition of 50 mg/l of calcium chloride to the tank protected against the toxic effect of this metal salt.	Jones (1938)
Lead nitrate	*Gasterosteus aculeatus* *Phoxinus phoxinus*	BSA	–	(O)	c e	Tap water was used to make up the solutions. The animals were attracted to a solution 0.04N - a positive reaction, they tended to swim into it. They tended to show avoidance reactions at concentrations of 0.004N down to 0.00002N. The minnow detected and avoided a 0.00004N solution. *P. phoxinus* minnows were much more sensitive to this chemical than *G. aculeatus*.	Jones (1948)
Lead nitrate	*Gambusia affinis*	BSA	–	240 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Lead nitrate	*Lebistes reticulatus*	BSCH	–	2.0 (27% K90)	a c d e	Sublethal effects found were retarded growth, increased mortality, and delayed sexual maturity.	Crandall and Goodnight (1962)

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Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Lead nitrate	Tubificid worms	BSA	–	49.0 (T1A) 27.5 (T1A)	a c	Knop's solution was used. TL_m levels for various pHs were determined for the tubificids and were found to be 5.8 to 9.7. Lead nitrate was more toxic at pH extremes of 6.5 and 8.5 than at 7.5.	Whitley (1968)
Lead oxide	*Gambusia affinis*	BSA	–	56,000 (T2A)	a c d e g	The effect of turbidity on the toxicity on the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Lead salts	*Salmo gairdnerii*	BSA	–	(O)	a e	This is a study of the effect of varying dissolved oxygen concentrations on the toxicity of selected chemicals. The toxicity of heavy metals, ammonia, and monohydric phenols increased as the dissolved oxygen in water was reduced. The most obvious reaction of fish to lowered oxygen content is to increase the volume of water passed over the gills, and this may increase the amount of poison reaching the surface of the gill epithelium. The concentration of the chemical in the water was not specified.	Lloyd (1961)
Lithium chloride	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, possible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compares this work with earlier work, and lists an extensive bibliography. In 0.166N solution, fish survived 234 minutes.	Powers (1918)
Lithium chloride	*Daphnia magna*	BSA	–	<7.2 (S)	a	Lake Erie water was used as diluent. Toxicity given as threshold concentration producing immobilization for exposure periods of 64 hr.	Anderson (1948)
D-lysergic acid	*Notemigonis crysoleucas* *Cyprinus carpio* *Carassius auratus* *Rhinichthys atratulus* *Semotilus atromaculatus* *Notropis cornutus* *Lepomis gibbosus* *Lebistes reticulatus* *Perca flavescens* *Catostomus commersoni* *Ameiurus nebulosus*	BSA	–	(O)	a	Lysergic acid and 45 of its derivatives were tested on a wide variety of aquatic animals. Various concentrations of the chemicals were used, from 0.5 to as high as 12.0 ppm. In nearly all cases, the chemical caused involuntary surfacing of the fish with no mortality at the above concentrations.	Loeb, et al (1965)

	Salmo trutta *Cottus cognatus* *Boleosoma nigrum* *Rana pipiens*						
Magnesium chloride	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, possible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compares this work with earlier work, and lists an extensive bibliography. In 0.313N solution, fish survived 88 minutes.	Powers (1918)
Magnesium chloride	*Daphnia magna*	BSA	–	740 (O)	a	Lake Erie water was used as diluent. Toxicity given as threshold concentration producing immobilization for exposure periods of 64 hr.	Anderson (1948)
Magnesium chloride	*Gambusia affinis*	BSA	–	17,750 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Magnesium chloride	*Daphnia magna*	BSA	–	3,391 (T1A) 3,489 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Magnesium nitrate	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, oossible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compares this work with earlier work, and lists an extensive bibliography. In 0.229N solution, fish survived 107 minutes.	Powers (1918)
Magnesium nitrate	*Gasterosteus aculeatus*	BSA	–	300 (K10)	–	Solutions were made up in tap water 3.0 to 5.0 cm stickleback fish were used as experimental animals. This paper points out that there is a marked relationship between the toxicity of the metals and their solution pressures. Those with low solution pressures were the most toxic.	Jones (1939)
Magnesium nitrate	*Biomorpholaria a. alexandrina*	BSA	–	(O)	a	The degree of tolerance for vector snails of biharziasis chemicals is somewhat dependent upon temperature. *B. a. alexandrina* tolerated a 24-hour exposure to 6200 ppm at 20 C.	Gohar and El-Gindy (1961)
Magnesium sulfate	*Gambusia affinis*	BSA	–	15,500 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Magnesium sulfate	*Biomorpholaria a. alexandrina* *Bulinus truncatus*	BSA	–	(O) 4000 (K1A)	a	The degree of tolerance for vector snails of biharziasis chemicals is somewhat dependent upon temperature. The temperature at which (K1A) occurred was 26 C for *Bulinus*. The tolerance for *Biomorpholaria* was 6200 ppm.	Gohar and El-Gindy (1961)
Magnesium sulfate	*Daphnia magna* *Lepomis macrochirus* *Lymnaea* sp (eggs)	BSA	–	3,803 (T4A) 19,000 (T1A) 10,530 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Malachite green	*Ictalurus punctatus*	BSA	–	0.19 (K2) 0.14 (T2A)	a c f i	The experiment was conducted at 77 C.	Clemens and Sneed (1958)
Malachite green	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
Malachite green (oxalate salt)	Channel catfish (fingerlings)	BSA	–	0.14 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Malachite green	*Micropterus salmoides* (fry)	BSA	–	0.025 (SB3)	a c d e f p	At least 90 percent of the fry survived for a period of 72 hours at the concentration listed.	Jones (1965)
	Lepomis macrochirus (fry)			0.001 (SB3)			
Malachite green	*Salmo gairdnerii*	BSA	–	0.39 (T2A)	f	Variance and the 95-percent confidence interval (C.I.) were also determined.	Willford (1966)
	Salmo trutta			0.34 (T2A)			
	Salvelinus fontinalis			0.26 (T2A)			
	Salvelinus namaycush			0.40 (T2A)			
	Ictalurus punctatus			0.20 (T2A)			
	Lepomis macrochirus			0.11 (T2A)			
Malachite green	*Salmo gairdnerii* *Rasbora heteromorpha*	BCFA	–	0.04 (threshold)	a d e	Aerated hard water was used. Threshold concentrations were examined by 4 methods. 1. Long term – survival related to concentration. 2. Short term – percentage kill in narrow range of concentrations. 3. Comparison of survival times. 4. Extrapolation of short-term results by plotting velocity of death against log of concentration.	Abram (1967)
Malachite green	*Salmo gairdnerii*	BSA	–	(C)	f	This report derives a mathematical equation for determining a threshold concentration for a toxicant. A concentration of 0.048 ppm of the compound will kill 50% of trout in about 18 days. 0.122 ppm was lethal to 50% in two and a half days.	
	Rasbora heteromorpha			(O)			
Maleic anhydride	*Gambusia affinis*	BSA	–	240 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Maleic hydrazide	*Salmo gairdnerii*	BSA	–	85 (T1A) 56 (T2A)	a e	Most of the weed-killer formulations in this study consisted of more than one substance, i.e., oils, emulsifiers, stabilizers, and other adjuvants.	Alabaster (1956)

Malonic acid	*Lepomis macrochirus*	BSA	–	150 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Manganese	*Lebistes reticulatus* *Bufo valliceps* (tadpoles) *Daphnia magna*	L	–	10,000 (K) 10,000 (K) 1,000 (K)	a c e	It is assumed in this experiment that the cations considered are toxic because they combine with an essential sulfhydryl group attached to a key enzyme. This treatment indicates that the metals which form the most insoluble sulfides are the most toxic. The log of the concentration of the metal ion is plotted against the log of the solubility product constant of the metal sulfide – a treatment that does not lend itself to tabulation. The cation toxicity cited is only an approximate concentration interpolated from a graph. Time of death was not specified.	Shaw and Grushkin (1967)
Manganese chloride	*Daphnia magna*	BSA	–	50 (O)	a	Lake Erie water was used as diluent. Toxicity given as threshold concentration producing immobilization for exposure periods of 64 hr.	Anderson (1948)
Manganese chloride	*Limnaea palustris* (eggs)	BSA	–	5 x 10^{-5} M (K1)	a c	Toxicity is given in molar concentrations for maximum direct mortality (kill) in 4 hours.	Morrill (1963)
Manganese disodium versenate	Channel catfish (fingerlings)	BSA	–	>500 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Manganese nitrate	*Gasterosteus aculeatus*	BSA	–	40 (K10)	–	Solutions were made up in tap water. 3.0 to 5.0 cm stickleback fish were used as experimental animals. This paper points out that there is a marked relationship between the toxicity of the metals and their solution pressures. Those with low solution pressures were the most toxic.	Jones (1939)
Mercuric acetate	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – T (3) Ma – T (3) So – T (3) Cv – T (3) Gp – T (3) Np – T (3)	Palmer and Maloney (1955)
Mercuric chloride	*Gasterosteus aculeatus*	BSA	–	0.008 (K10)	–	Solutions were made up in tap water. 3.0 to 5.0 cm stickleback fish were used as experimental animals. This paper points out that there is a marked relationship between the toxicity of the metals and their solution pressures. Those with low solution pressures were the most toxic.	Jones (1939)
Mercuric chloride	*Balanus balanoides*	BSA	–	1.0 (O)	–	The concentration listed was lethal to 90% of adult barnacles in 2 days.	Clarke (1947)
Mercuric chloride	*Pygosteus pungitius*	BCF	–	(O)	a c	The fish were immersed in solutions of 0.003, 0.002, 0.0003, and 0.00004N mercuric chloride. Survival times in these solutions were respectively, 14, 22, 31, and 100 minutes.	Jones (1947)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Mercuric chloride	*Daphnia magna*	BSA	–	<0.006 (O)	a	Lake Erie water was used as diluent. Toxicity given as threshold concentration producing immobilization for exposure periods of 64 hr.	Anderson (1948)
Mercuric chloride	*BOD*	L	–	1.0 (O)	j	"Toxicity is expressed as 80 percent reduction in oxygen utilization.	Ingols (1955)
Mercuric chloride	Sewage organisms	BOD	–	(O)	–	There was a slow increase in toxicity of mercury from 0.02 to 0.2 ppm. Beyond this there was a sharp rise in the toxicity until at approximately 2.0 ppm there was complete bacteriostasis or an absence of BOD at this concentration.	Ingols (1954)
Mercuric chloride	Sewage organisms	BOD	–	0.61 (TC_{50})	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Mercuric iodide	*Artemia salina*	BSA	–	31.0 (O)	a c	All tests were conducted in seawater. Toxicity values reported are relative to that of mercuric chloride expressed as unity. Mechanism of action is discussed, as well as synergistic action of two poisons administered simultaneously.	Corner and Sparrow (1956)
	Acartia clausi			1.7 (O)			
	Elminius modestus			2.6 (O)			
Mercury	*Lebistes reticulatus*	BSA	–	0.01 (K)	a c e	It is assumed in this experiment that the cations considered are toxic because they combine with an essential sulfhydryl group attached to a key enzyme. This treatment indicates that the metals which form the most insoluble sulfides are the most toxic. The log of the concentration of the metal ion is plotted against the log of the solubility product constant of the metal sulfide – a treatment that does not lend itself to tabulation. The cation toxicity cited is only an approximate concentration interpolated from a graph. Time of death was not specified.	Shaw and Grushkin (1967)
	Bufo valliceps (tadpoles)			0.1 (K)			
	Daphnia magna			0.1 (K)			
Mercury	*Maia squinado*	BSA	–	10 (SB 28)	–	Results showed that the highest mercury concentrations occurred in the gills and internal organs. Concentrations were minute in the blood and there was none in the urine.	Corner (1959)
Mercury compounds	*Esox leucius*	FL	Denmark	(O)	–	Mercury may become a water contaminant from seed dressings in agriculture, fungicides in pulp and paper mills, and from the chlorine alkali industry. Pike was chosen as an indicator organism, and many analyses were given for mercury content of pike. In water with a mercury content of 0.07 ppb, pike were found with a concentration of 3000 times that concentration. Analyses were reported of pike containing from 60 to 2500 ppb. One value as high as 8000 ppb was reported. There are many organisms capable of accumulating mercury from water.	Johnels, et al (1967)

Methanol	Sewage organisms	BOD	–	(NTE)	–	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
2'-methoxy-5'-chloro-3-nitro-salicylanilide	Sea lamprey (larva) *Salmo gairdneri* (fingerling)	BSA	–	0.7 (LD_{100}) 1.0 (LD_{25})	See Applegate, et al (1957-1958)	This paper deals with the comparative toxicity of halonitro-salicylanilides to sea lamprey and fingerling rainbow trout as a function of substituent loci.	Starkey and Howell (1966)
Methyl alcohol	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, possible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compares this work with earlier work, and lists an extensive bibliography. In a concentration of 25 cc per liter, fish survived 206 minutes.	Powers (1918)
Methyl alcohol	*Daphnia magna*	BSA	–	32,000 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Methyl alcohol	*Semotilus atromaculatus*	BSA	–	8,000 to 17,000 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
Methylamine HCl	*Microcystis aeruginosa*	L	–	100 (K)	a	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
p-methylamino-phenol	*Daphnia magna*	BSA	–	0.5 (K2)	a	An attempt was made to correlate the biological action with the chemical reactivity of selected chemical substances. Results indicated a considerable correlation between the aquarium fish toxicity and antiautocatalytic potency of the chemicals in marked contrast to their toxicity on systemic administration.	Sollman (1949)
2'-methyl-3'-chloro-3-nitro salicylanilide	Sea lamprey (larva) *Salmo gairdneri* (fingerling)	BSA	–	0.7 (LD_{100}) 1.0 (LD_{25})	See Applegate, et al (1957-1958)	This paper deals with the comparative toxicity of halonitro-salicylanilides to sea lamprey and fingerling rainbow trout as a function of substituent loci.	Starkey and Howell (1966)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
2'-methyl-4'-chloro-3-nitro-salicylanilide	Sea lamprey (larva) *Salmo gairdneri* (fingerling)	BSA	–	0.5 (LD_{100}) 0.7 (LD_{25})	See Applegate, et al (1957-1958)	This paper deals with the comparative toxicity of halonitro-salicylanilides to sea lamprey and fingerling rainbow trout as a function of substituent loci.	Starkey and Howell (1966)
2'-methyl-5'-chloro-3-nitro-salicylanilide	Sea lamprey (larva) *Salmo gairdneri* (fingerling)	BSA	–	0.5 (LD_{100}) 0.9 (LD_{25})	See Applegate, et al (1957-1958)	Comment same as above.	Starkey and Howell (1966)
Methyldodecyl-benzyl trimethyl ammonium chloride	*Cylindrospermum licheniforme (Cl)* *Gleocapsa* sp *(G)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – T (3), PT (7) G – PT (3) So – T (14) Cv – PT (7) Gp – T (14) Np – T (14)	Palmer and Maloney (1955)
Methyl dodecyl benzyl trimethyl ammonium chloride plus tridecyl methyl hydroxy ethyl imidazolinium chloride	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2 0 (O)	a	Comment same as above except that: Cl – NT Ma – NT So – PT (14) Cv – PT (14) Gp – NT Np – NT	Palmer and Maloney (1955)
1,1'-methylenedi-2-naphthol [bis(2-hydroxy-naphthyl) methane]	*Ptychocheilus oregonensis*	FR	Idaho	(O)	a	The creek was treated with 0.75 lb of chemical. Surface temperature remained at 61 F during the 3-hr treatment. The inlet of the stream was treated with 0.05 ppm for 2 hr after the lagoon was treated. Four and one-half hours after the start of the treatment, four northern squawfish were found dead. The next morning numerous dead squawfish were observed on the bottom of the lagoon. No live squawfish were seen and no dead fish of any other species were observed.	MacPhee and Ruelle (1968)

1,1'-methylenedi-2-naphthol [bis(2-hydroxy-naphthyl) methane]		BSA	–		a e	Experiments were conducted in vessels containing 10 liters of water.	McPhee and Ruelle (1968)
	Ptychocheilus oregonensis			0.006 (K4A)		Temperature was held at 65 F.	
	Onchorhynchus tshawytscha			0.008 (K4A)		Temperature was held at 60 F.	
	Onchorhynchus kisutch			0.010 (K4A)		Temperature was held at 55 F.	
	Salmo gairdneri			0.015 (K4A)		Temperature was held at 50 F.	
						This chemical had no toxic effect upon Chinook salmon, Coho salmon or steelhead trout at the temperature and concentration indicated for squawfish.	
Methylene blue – see Appendix B							
Methyl mercaptan	*Onchorlynchus tshawytscha*	BSA	–	0.9 (K5)	a d e	This chemical is one of a number that may be found in Kraft mill waste effluents. Data are expressed as minimum lethal concentration for 5 days.	Haydu, et al (1952)
	Oncorhyncus kisutch			1.75 (K5)			
	Salmo clarkii clarkii			1.2 (K5)			
Methyl mercury chloride	*Venus japonica* *Hurmomya mutabilis*	F	Japan	(O)	–	Human beings, cats, and waterfowl eating shellfish from Minamata Bay all succumbed to a strange poisoning. At autopsy, clinicopathological changes similar to those induced in mercury poisoning, were found in the cerebellum, and the cerebral cortices. The shellfish were examined chemically and were found to contain as much as 85 mg/kg. The mercury compound was identified and found in the effluent waste from a chemical plant making acetyldehyde. A treatment was found to eliminate the pollutant.	Irukayama (1966)
Methyl mercury dicyandiamide	*Procambarus clarkii* (juvenile)	BSA	–	0.083 (T5A)	a c d o	The pesticides studied in this report are widely used in rice culture in Louisiana and are toxic to crawfish.	Hendrick and Everett (1965)
Methyl methacrylate	*Pimephales promelas*	BSA	–	150 (T4A)	a c d e f	Most fish survived at test concentrations of about one half, or slightly more, of the TL_m value. No attempt was made to estimate 100 percent survival.	Pickering and Henderson (1966)
	Lepomis macrochirus			250 (T4A)			
	Carassius auratus			240 (T4A)			
	Lebistes reticulatus			420 (T4A)			
2-methyl-naphtho-quinone	*Pomoxis nigromaculatus* *Notropis atherinoides atherinoides* *Hyborhynchus notatus* *Ambloplites rupestris rupestris* *Huro salmoides*	BSA	–	0.3 to 0.6 (K1-2)	o	Aerated spring water was used as the test medium. Effective algicidal concentrations were also toxic to fish.	Fitzgerald, et al (1952)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
5'-methyl-o-salicylanisidide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	10 (K2) 10 (K2)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule.	Walker, et al (1966)
Methyl vinyl ketone	Sewage microorganisms	BOD	–	1.5 (O)	–	The chemical was studied as to how low levels (ppm) may affect BOD in domestic sewage. The chemical was toxic at the level stated.	Oberton and Stack (1957)
Molybdic anhydride	*Pimephales promelas*	BSA	–	(H) 370 (T4A) (S) 70 (T4A)	a c d f	Both hard (H) and soft (S) water were used.	Tarzwell and Henderson (1960)
Monoamyl-amine	*Semotilus atromaculatus*	BSA	–	30 to 50 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
Mono-n-butylamine	*Semotilus atromaculatus*	BSA	–	30 to 70 (CR)	a e	Comment same as above.	Gillette, et al (1952)
Monoethyl-ethanolamine	*Semotilus atromaculatus*	BSA	–	40 to 70 (CR)	a e	Comment same as above.	Gillette, et al (1952)
Mono-isobutylamine	*Semotilus atromaculatus*	BSA	–	20 to 60 (CR)	a e	Comment same as above.	Gillette, et al (1952)
Mono-iso-propylamine	*Semotilus atromaculatus*	BSA	–	40 to 80 (CR)	a e	Comment same as above.	Gillette, et al (1952)
Mono-methylamine	*Semotilus atromaculatus*	BSA	–	10 to 30 (CR)	a e	Comment same as above.	Gillette, et al (1952)
Mono-n-propylamine	*Semotilus atromaculatus*	BSA	–	40 to 60 (CR)	a e	Comment same as above.	Gillette, et al (1952)
Mono-sec-butylamine	*Semotilus atromaculatus*	BSA	–	20 to 60 (CR)	a e	Comment same as above.	Gillette, et al (1952)
Naphthenic acid	*Lepomis macrochirus*	BSA	–	5.6 (T4A)	a c e	Increase in temperature seemed to increase toxicity of this chemical. Low dissolved oxygen reduced toxicity of some chemicals in this study. Toxicity values may be 20% higher in hard versus soft water.	Cairns (1957)

Naphthenic acid	*Lepomis macrochirus* *Physa heterostropha*	BSA	–	(N) 5.6 (T4A) (L) 2.0 (T4A) (N) 6.6-7.5 (T4A) N (L) 2.0 (T4A) L	a e	Modified Chu No. 14 test medium was used. Toxicity is given both for "normal" O_2 (5-9 ppm), (N), and with "low" O_2 (2 ppm DO), (L). High and low threshold concentration and concentration percent of survival are also presented.	Cairns and Scheier (1958)
Naphthenic acid	*Lepomis macrochirus* *Physa heterostropha*	BSA	–	5.6 (T4A) 2.0 (T4A) 6.6-7.5 (T4A) 2.0 (T4A)	a e	Normal oxygen content in water. Low oxygen content in water. Normal oxygen content in water. Low oxygen content in water.	Cairns (1965)
Naphthenic acid	*Nitzschia linearis* *Physa heterostropha* *Lepomis macrochirus*	BSA	–	43.1 (T5A) 6.6-7.5 (T4A) 5.6 (T4A)	a c e	The purpose of this experiment was to determine whether there was a constant relationship between the responses of these organisms. From the data presented, there was no apparent relationship of this type. Therefore the authors advise that bioassays on at least 3 components of the food web be made in any situation.	Patrick, et al (1968)
Naphthenic acids	*Lepomis macrochirus* *Physa heterostropha*	BSA	–	5.79 (T4A) 6.60 (T1A)	a c d f	This chemical is a mixture of compounds with a general formula of $CnH_2N\text{-}O_2$, $CnH_2N\text{-}4O_2$, or $CnH_2N\text{-}6O_2$, which are widely used in insecticidal formulations. The experiments were conducted in a synthetic dilution water of controlled chemical composition. In hard water, the chemical was somewhat less toxic.	Cairns and Scheier (1962)
Naphthenic acids	*Brachydanio rerio* (adults) (eggs) *Lepomis macrochirus*	BSA	–	16.3 (T2A) 3.5 (T2A) 5.6 (T2A)	a c d e f	The test dilutions were made up from distilled water and ACS grade chemicals. Temperature was held at 24 C and the solution was aerated to maintain a dissolved oxygen content of 5-9 ppm.	Cairns, et al (1965)
Naphthenic acids	*Lepomis macrochirus*	BSA	–	5.6 (T4A)	a c d e	All fish were acclimatized for 2 weeks in a synthetic dilution water.	Cairns and Scheier (1968)
Naphthenic acid (a) - cyanide (b) - chromium (c) mixture	*Lepomis macrochirus*	BSA	–	(a) 4.74 (T4A) (b) .026 (T4A) (c) 0.019 (T4A)	a c d e	Comment same as above.	Cairns and Scheier (1968)
Naphthalene	*Gambusia affinis*	BSA	–	165 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
a-naphthol	*Microcystis aeruginosa*	L	–	100 (K)	a	The chemical was tested on a 5-day algae culture. 1×10^6 to 2×10^6 cells/ml, 75 ml total volume. CHU No. 10 medium was used.	Fitzgerald, et al (1952)
b-naphthol	*Microcystis aeruginosa*	L	–	100 (K)	a	Comment same as above.	Fitzgerald, et al (1952)
1,4-naphthoquinone	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	Comment same as above.	Fitzgerald, et al (1952)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
1,4-naphthoquinone	*Pomoxis nigromaculatus* *Notropis atherinoides* *Hyborhynchus notatus* *Ambloplites rupestris* *Huro salmoides*	BSA	–	0.3 to 0.6 (K1-2)	e	Aerated spring water was used as the test medium. Effective algicidal concentrations were also toxic to fish.	Fitzgerald, et al (1952)
a-naphthylamine	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – PT (7) Ma – T So – T (7) Cv – T (7), PT (21) Gp – T (7), PT (21) Np – T (3), PT (7)	Palmer and Maloney (1955)
b-naphthaquinoline	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Comment same as above except that Cl – PT Ma – NT So – PT Cv – PT (7) Gp – T (7), PT (21) Np – T (3), PT (7)	Palmer and Maloney (1955)
Nickel	Rainbow trout	FR	Scotland	25 (T2)	a c e f l m	This work represents an extension of laboratory studies of the toxicity of complex effluents to investigations of rivers.	Herbert, et al (1965)
Nickel	*Lebistes reticulatus*	L	–	10 (K)	a c e	It is assumed in this experiment that the cations considered are toxic because they combine with an essential sulfhydryl group attached to a key enzyme. This treatment indicates that the metals which form the most insoluble sulfides are the most toxic. The log of the concentration of the metal ion is plotted against the log of the solubility product constant of the metal sulfide – a treatment that does not lend itself to tabulation. The cation toxicity cited is only an approximate concentration interpolated from a graph. Time of death was not specified.	Shaw and Grushkin (1967)
	Bufo valliceps (tadpoles)			100 (K)			
	Daphnia magna			10 (K)			

Nickel ammonium sulfate	Sewage organisms	BOD	–	134 (O)	–	Various metal salts were studied in relation to how they affected the BOD of both raw and treated sewage as well as how they affected the processing of sewage in the treatment plant. BOD was used as the parameter to measure the effect of the chemical. The chemical concentration cited is the ppm required to reduce the BOD values by 50%. This chemical was tested in an unbuffered system.	Sheets (1957)
Nickel chloride	*Daphnia magna*	BSA	–	<0.7 (O)	a	Lake Erie water was used as diluent. Toxicity given as threshold concentration producing immobilization for exposure periods of 64 hr.	Anderson (1948)
Nickel chloride	Sewage organisms	BOD	–	38 (O)	–	Various metal salts were studied in relation to how they affected the BOD of both raw and treated sewage as well as how they affected the processing of sewage in the treatment plant. BOD was used as the parameter to measure the effect of the chemical. The chemical concentration cited is the ppm required to reduce the BOD values by 50%. This chemical was tested in an unbuffered system.	Sheets (1957)
Nickelous chloride	*Pimephales promelas*	BSA	–	(H) 24 (T4A) (S) 4 (T4A)	a c d f	Both hard (H) and soft (S) water were used.	Tarzwell and Henderson (1960)
Nickel chloride	*Limnaea palustris* (eggs)	BSA	–	8×10^{-6}M (K1)	a c	Toxicity is given in molar concentrations for maximum direct mortality (kill) in 4 hours.	Morrill (1963)
Nickel chloride	*Pimephales promelas* *Lepomis macrochirus* *Carassius auratus* *Lebistes reticulatus*	BSA	–	(S) 5.18 (T4A) (H) 42.4 (T4A) (S) 5.18 (T4A) (H) 39.6 (T4A) (S) 9.82 (T4A) (S) 4.45 (T4A)	c d e f	(S) Soft water (H) Hard water Values are expressed as mg/l of metal.	Pickering and Henderson (1965)
Nickel-cyanide complex	*Lepomis macrochirus* (juvenile)	BSA	–	(O)	a c d f p	In solution with a calculated CN content of 100 to 500 ppm, the median resistance time was 143 to 540 min. There was no apparent correlation between median resistance time and concentration.	Doudoroff, et al (1966)
Nickel cyanide complex [sodium cyanide (600 ppm CN^-) plus nickelous sulfate (355 ppm Ni)]	*Pimephales promelas*	BSA	–	0.95 (T4A)	a c d	Synthetic soft water was used. Toxicity data given as number of test fish surviving after exposure at 24, 48, and 96 hr. TL_m values were estimated by straight-line graphical interpolation and given in ppm CN^-. Additional toxicity data in which total alkalinity was varied, 730 (T-4) with 192 ppm $CaCO_3$ alkalinity.	Doudoroff, et al (1956)
Nickel-ferrocyanide complex	*Pimephales promelas*	BSA	–	1.0 ppm CN^- 0.8 ppm Cu 0.4 ppm Fe (non-toxic after 4 days)	a c	Synthetic soft water was used. Toxicity data given as number of test fish surviving.	Doudoroff, et al (1956)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Nickel nitrate	*Gasterosteus aculeatus*	BSA	–	0.8 (K10)	–	Solutions were made up in tap water. 3.0 to 5.0 cm stickleback fish were used as experimental animals. This paper points out that there is a marked relationship between the toxicity of the metals and their solution pressures. Those with low solution pressures were the most toxic.	Jones (1939)
Nickel nitrate	Sewage organisms	BOD	–	64 (O)	–	Various metal salts were studied in relation to how they affected the BOD of both raw and treated sewage as well as how they affected the processing of sewage in the treatment plant. BOD was used as the parameter to measure the effect of the chemical. The chemical concentration cited is the ppm required to reduce the BOD values by 50%. This chemical was tested in an unbuffered system.	Sheets (1957)
Nickel sulfate	Sewage organisms	BOD	–	16 (O)	–	Comment same as above.	Sheets (1957)
Nickel sulfate	*Salmo gairdneri* *Salmo trutta* *Salvelinus fontinalis* *Salvelinus namaycush* *Ictalurus punctatus* *Lepomis macrochirus*	BSA	–	160 (T2A) 270 (T2A) 242 (T2A) 75 (T2A) 165 (T2A) 495 (T2A)	a f	Variance and the 95-percent confidence interval (C.I.) were also determined.	Willford (1966)
Nitric acid	*Daphnia magna*	BSA	–	107 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposures.	Anderson (1944)
Nitric acid	*Gambusia affinis*	BSA	–	75 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
3-nitro-4 acetoxybenzoic acid	*Cylindorspermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – NT Ma – NT So – NT Cv – NT Gp – NT Np – NT	Palmer and Maloney (1955)

3-nitrobenz-anilide	*Salmo gairdnerii* *Carassius auratus*	BSA	—	10 (K2) 10 (K2)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule.	Walker, et al (1966)
Nitrobenzene	Sewage organisms	BOD	—	630 (TC_{50})	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
3-nitro-4-methoxy-benzoic acid	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	—	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – NT Ma – PT (3) So – PT (7) Cv – PT (3) Gp – T (3) Np – NT	Palmer and Maloney (1955)
4'-nitro-o-salicylanisidide	*Salmo gairdnerii* *Carassius auratus*	BSA	—	10 (K 3 hr) 10 (K2)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule.	Walker, et al (1966)
o-nitro-phenol	*Lepomis macrochirus*	BSA	—	46.3 - 51.6 (T2A)	a c d e f g i o	Assays are completely described and autopsy data are reported.	Lammering and Burbank (1961)
p-nitrophenyl-hydrazine hydrochloride	*Microcystis aeruginosa*	L	—	50 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
p-nitrophenyl-hydrazine	*Microcystis aeruginosa*	L	—	100 (K)	a, etc	Comment same as above.	Fitzgerald, et al (1952)

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Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
2'-nitro-p-salicylanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	10 (K 3 hr) 10 (K 3 hr)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule.	Walker, et al (1966)
3-nitro-2',6'-salicyloxylidide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	10 (K2) 10 (K2)	a	Comment same as above.	Walker, et al (1966)
3-nitrosalicylanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	10 (K2A) 10 (K2A)	a	Comment same as above.	Walker, et al (1966)
3-nitro-2',3-salicyloxylidide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	1.0 (K2A) 10.0 (K2A)	a	Comment same as above.	Walker, et al (1966)
3-nitro-2',5-salicyloxylidide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	10.0 (K 3 hr) 10.0 (K2)	a	Comment same as above.	Walker, et al (1966)
3-nitro-2',4'-salicyloxylidide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	1.0 (K2) 10.0 (K 3 hr)	a	Comment same as above.	Walker, et al (1966)

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Nonyl phenol ethoxylate	*Salmo gairdnerii* (12 days after hatching) (25 days after hatching, fry) (210 days after hatching, fingerling)	BCFA	–	13.5 (K) 3 hr 5.2 (K) 6 hr 4.4 (K) 3 hr 2.3 (K) 6 hr 8.0 (K) 3 hr 5.2 (K) 6 hr	a c d e i	Successive developmental stages of the organism showed marked differences in resistance to the chemical. Changes in resistance could not be correlated with changes in respiratory activity of the fish but rather with their water metabolism.	Marchetti (1965)
p-octyl diphenylamine	*Daphnia magna*	BSA	–	>40 (K2)	a	An attempt was made to correlate the biological action with the chemical reactivity of selected chemical substances. Results indicated a considerable correlation between the aquarium fish toxicity and antiautocatalytic potency of the chemicals in marked contrast to their toxicity on systemic administration.	Sollman (1949)
Oxydipropionitrile	*Pimephales promelas* *Lepomis macrochirus* *Lebistes reticulatus*	BSA	–	(H) 3600 (T4A) (S) 3900 (T4A) (S) 4200 (T4A) (S) 4450 (T4A)	c d e f	(H) Value in hardwater (S) Value in softwater The chemical produced no change in flavor of the cooked bluegill.	Henderson, et al (1960)
Oxalic acid	*Daphnia magna*	BSA	–	95 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Oxalic acid	Sewage organisms	BOD	–	43 (TC_{50})	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Pentachlorophenol	Green sunfish	BSA	–	(O)	–	Pentachlorophenol was repellent to the green sunfish at 20 mg/l but the fish were indifferent in response to 5.0 mg/l.	Summerfelt and Lewis (1967)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
pH	*Gasterosteus aculeatus*	BSA	–	(O)	c e	Tap water was used to make up the solutions. The fish avoided water more acid than a pH of 5.6 or one more alkaline than 11.4.	Jones (1948)
pH	*Salmo gairdnerii*	BSA	–	(O)	a b c d e f p	The pH value at which acid solutions proved lethal to rainbow trout within 1 day was unaffected by the pH value to which the fish had been acclimatized (pH 6.5-8.4). Fifty percent of a population of yearling rainbow trout were killed in about 1 day at a pH value of 3.6 when little free CO_2 was present; where in the presence of 50 ppm free CO_2, a pH value of 5.6 killed 50 percent of a population of fingerling trout in 15 days. In water of low free CO_2 content, the relation between pH value and log median period of survival was linear for survival times between about 3 hr and 15 days. Exposure to pH values below 5.0 for about 3 months might be harmful to rainbow trout when little free CO_2 is present in the water.	Lloyd and Jordan (1964)
Phenanthraquinone	*Pomoxis nigromaculatus* *Notropis atherinoides atherinoides* *Hyborhynchus notatus* *Ambloplites rupestris rupestris* *Huro salmoides*	BSA	–	(O)	e	Aerated spring water was used as the test medium. No effect was observed on fish after 2 days of exposure, even with excess solid dispersed in water. At algicidal concentrations, this compound was not toxic to the fish studied.	Fitzgerald, et al (1952)
o-phenanthroline	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1×10^6 to 2×10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
Phenazine-1-carboxylic acid	*Anabaena flos-aquae* *Notemigonous crysoleucas*	L	–	100 (O) 0.1 to 10.0 (O)	–	Value given is concentration for complete inhibition of *A. flos-aquae.* No harmful effect to *N. crysoleucas* was noted at the concentrations evaluated.	Toohey, et al (1965)
Phenol	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, possible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compares this work with earlier work, and lists an extensive bibliography. In a concentration of 0.259 g/liter, fish survived 104 minutes.	Powers (1918)
Phenol	*Carassius auratus*	BSA	–	125 to 372 (K 8 hr) 83.2 (O) 41.6 (O)	a	Temperature in test containers was maintained at 27 ± .2 C. Goldfish tested weighed between 2 and 4 g. Phenol, 83.2 ppm (mg per liter), killed 86% of the fish in 8 hr; 41.6 (mg per liter) killed 67% in 8 hr.	Gersdorff and Smith (1940)

Phenol	*Anopheles quadrimaculatus* Goldfish Shiner minnows	BSA	–	(O)	–	Under the conditions of this experiment, this chemical (diluted 1 to 30) applied at rates of 10 to 95 gallons per acre was less effective than kerosene in controlling mosquitos. In the laboratory, at the rate of 50 gallon per acre, 100 percent of fish were killed but only 16 percent of the larvae. Phenol did not appear to be a desirable larvacide for general mosquito control.	Knowles, et al (1941)
Phenol	*Carassius auratus*	BSA	–	0.103 (K)	a	Goldfish weighed between 2 and 4 g. Temperature was maintained at 27.0 ± 0.2 C.	Gersdorff (1943)
Phenol	*Daphnia magna*	BSA	–	94 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Phenol	*Hyborhynchus notatus*	BSA	–	–	–	Fish in aquaria were trained to detect and distinguish between phenol and p-chlorophenol at levels as low as 0.0005 ppm. The fish could also distinguish o-chlorophenol from the two other compounds. The training method is described.	Hasler and Wisby (1949)
Phenol	*Daphnia magna*	BSA	–	28.9 (K2)	a	An attempt was made to correlate the biological action with the chemical reactivity of selected chemical substances. Results indicated a considerable correlation between the aquarium fish toxicity and antiautocatalytic potency of the chemicals in marked contrast to their toxicity on systemic administration.	Sollman (1949)
Phenol	*Phoxinus phoxinus*	BCFA	–	0.04% (K 4 min) 0.01% (K 8 min) 0.004% (K 24 min) 0.0004% (K 40-50 hr)	a c	Tap water was used as diluent. The apparatus used was a 34 mm diameter tube fitted to permit sharp vertical separation of water and test solutions. With this system, avoidance data could be obtained. Toxicity is given as average survival time of replicates. Fish did not avoid phenol in the <0.04% range.	Jones (1951)
Phenol	*Semotilus atromaculatus*	BSA	–	10 to 20 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
Phenol	*Lepomis macrochirus*	BSA	–	20.5 (T4A) 19.3 (T2A)	a c d e	Chu No. 14 modified medium was used as dilution water. The fish were transferred each 24 hours into new test solutions because of phenol loss due to aeration.	Trama (1955)
Phenol	*Lepomis macrochirus*	BCFA	–	11.5 (T4A)	a c e f	Test water was composed of distilled water with CP grade chemicals and was aerated throughout the 96-hour exposure period. The phenol concentration was kept constant during the test period.	Cairns and Scheier (1955)
Phenol	*Gambusia affinis*	BSA	–	56 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Phenol	Sewage organisms	BOD	–	1600 (TC_{50})	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Phenol	Channel catfish (fingerlings)	BSA	–	16.7 (K 48 hr A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Phenol	*Lepomis macrochirus*	BSA	–	11.5 (T4A)	a c d e i	A "control" was prepared by adding required chemicals to distilled water, and this was constantly aerated. Data reported are for larger fish, app 14.24 cm in length. Data for smaller fish are also in the report.	Cairns and Scheier (1959)
Phenol	*Lepomis macrochirus*	BSA	–	22.2 (T2A)	a c d e f g i o	Assays are completely described, and autopsy data are reported.	Lammering and Burbank (1961)
Phenols (monohydric)	*Salmo gairdnerii*	BSA	–	(O)	a e	This is a study of the effect of varying dissolved oxygen concentrations on the toxicity of selected chemicals. The toxicity of heavy metals, ammonia, and monohydric phenols increased as the dissolved oxygen in water was reduced. The most obvious reaction of fish to lowered oxygen content is to increase the volume of water passed over the gills, and this may increase the amount of poison reaching the surface of the gill epithelium. The concentration of the chemical in the water was not specified.	Lloyd (1961)
Phenol	*Hydropsyche* *Stenonema*	BSA	–	30.0 (T2A) 14.5 (T2A)	a	Soft water used as diluent water.	Roback (1965)
Phenol	*Protococcus* sp *Chlorella* sp *Dunaliella euchlora* *Phaeodactylum tricornutum* *Monochrysis lutheri*	BSA	–	500 (K) 500 (K) 500 (K) 100 (NG) 100 (NG)	a	This paper concerns the growth of pure cultures of marine plankton in the presence of toxicants. Results were expressed as the ratio of optical density of growth in the presence of toxicants to optical density in the basal medium with no added toxicants. NG = no growth, but the organisms were viable.	Ukeles (1962)
Phenol	"Aquatic flora and fauna"	FR	Luxembourg	5.0-10.0 (O)	c e	Destruction of all flora and fauna of the river occurred in highly polluted zone (10 ppm), slight affects occurred at 3.0-10 ppm, and practically no damage occurred at concentrations below 3.0 ppm.	Krombach and Barthel (1963)

Phenol	*Rasbora heteromorpha*	BSA	–	6.0 (O)	–	For many toxins the rate of mortality is found to be a linear function of the logarithm of the concentration of the poison; whereas the comparable relation between the logarithms of the survival time and the concentration is nonlinear. The linear function can be exploited to provide comparatively simple methods of estimating long-term survival concentrations. An application of this is suggested for defining realistic standards of toxicity. At the concentration listed, there was a 30 percent mortality in about 2 weeks.	Abram (1964)
Phenol	Fish	BSA	–	1.4 x 10^{-4} M (K)	a c	Avoidance behavior of test fish to toxic chemicals is given. Toxicity is given as the lowest lethal concentration (molar). Ratios of avoidance and lowest lethal concentrations are presented and discussed.	Ishio (1965)
Phenol	Fish	FR	Ohio	.016 (O)	–	Following shut-down of steel mills due to a strike, phenols were 3.0 ppb in the Ohio River during the shut-down as compared to 16.0 ppb after the mills resumed operation. Threshold odor intensity and dissolved-iron content were 2 to 8X greater after start-up of the mills than during the shut-down period. Appearance or increased abundance of such "clean-water fish" as big-eye chub, common sucker, stoneroller, creek chub, sand shiner, mimic shiner, common shiner, and bluntnose minnow occurred while mills were shut down. Additionally, small minnows increased 20X during this period. The authors note that these facts are indicative of a marked betterment of the environment. Further, they suggest that the faunal monotony of the upper Ohio River is more closely related to industrial than to domestic discharges.	Krumholz and Minckley (1964)
Phenol	*Carassius auratus*	BCSA	–	(O)	a	A 5% solution of phenol in water was injected in the muscular masses of the fish tails at various levels. The MLD (minimal lethal dose) of phenol was found to be 230 mg/kg. Goldfish are unable to conjugate phenol, while showing a high efficiency in excreting the drug unchanged.	Boni (1965)
Phenols	Rainbow trout	FR	Scotland	4.4 (T2)	a c e f l m	This work represents an extension of laboratory studies of the toxicity of complex effluents to investigations of rivers.	Herbert, et al (1965)
Phenol	*Daphnia magna* (young) *Daphnia magna* (adult) *Lepomis macrochirus* *Mollienesia latopinna*	BSA	–	17 (T1A) 7 (T2A) 61 (T1A) 21 (T2A) 63 (T1A) 22 (T2A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Phenol	*Pimephales promelas* *Lepomis macrochirus* *Carassius auratus* *Lebistes reticulatus*	BSA	–	29 (T4A) 26 (T4A) 46 (T4A) 44 (T4A)	a c d e f	Most fish survived at test concentrations of about one half, or slightly more, of the TL$_m$ value. No attempt was made to estimate 100 percent survival.	Pickering and Henderson (1966)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Phenol	*Salmo gairdnerii*	BSA	–	1.5 (T2A)	a c d e f	Test solution used in this study was sea water collected from the North Sea, then diluted with distilled water. Sensitivity of fish to poisoning by phenol increased as salinity increased.	Brown, et al (1967)
Phenol	*Salmo gairdnerii* *Salmo salar*	BSA	–	5.2 (T2)	a c d e f	Fish were acclimatized to 14 days in salt water.	Brown, et al (1967)
Phenol	*Salmo gairdnerii*	BSA	–	(O)	a c d e f p	Fish were acclimatized to the temperature of the test water over a period of 24-36 hr and then held at the test temperature without being fed for 24 hr before testing. Results showed that the resistance to poisoning by phenol increases with increase in temperature up to at least 18 C, at which the L2 is almost twice that at 6 C. A similar relationship exists with gas-liquor phenols. The response of test populations showed the least viability at 12 C.	Brown, et al (1967)
Phenol	*Nitzschia linearis* *Physa heterostropha* *Lepomis macrochirus*	BSA	–	258 (T5A) 94.0 (T4A) 13.5 (T4A)	a c e	The purpose of this experiment was to determine whether there was a constant relationship between the responses of these organisms. From the data presented, there was no apparent relationship of this type. Therefore the authors advise that bioassays on at least 3 components of the food web be made in any situation.	Patrick, et al (1968)
Phenol	*Salmo gairdnerii*	BCFA	–	7.5 (T2A)	a c d e f	Phenol rapidly damaged the gills of trout. Experiments were conducted at levels above and below the LC_{50} and for varying periods of time. Even at the level which killed only 20% of the fish in 48 hours, sufficient damage was done within one week to impair survival of the individual and affect reproduction. (This concentration was not specified, but was probably 6.5 ppm.)	Mitrovic, et al (1968)
Phenol	*Salmo gairdnerii*	BSA	–	4.58 to 5.8 (T2A)	a c d e f o	The concentration killing a half batch of fish in 2 days provides a reasonable estimate of the threshold concentration. The lethality of this chemical depends upon the temperature and concentration of dissolved oxygen.	Brown (1968)
Phenylhydrazine hydrochloride	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
4'-phenylazo-3-nitrosalicylanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	0.1 (K2A) 1.0 (K 3 hr) 1.0 (K2A) 10.0 (K2A)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule.	Walker, et al (1966)

p-phenylene-diamine	*Daphnia magna*	BSA	–	5.74 (K2)	a	An attempt was made to correlate the biological action with the chemical reactivity of selected chemical substances. Results indicated a considerable correlation between the aquarium fish toxicity and antiautocatalytic potency of the chemicals in marked contrast to their toxicity on systemic administration.	Sollman (1949)
Phenylmercuric acetate (10% soln.)	*Ictalurus punctatus*	BSA	–	2.30 (K2) 1.46 (T2A)	a c f i	The experiment was conducted at 68 C.	Clemens and Sneed (1958)
Phenylmercuric acetate	Channel catfish (fingerlings)	BSA	–	4.1 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Phenylmercuric hydroxide	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – T (3) Ma – T (3) So – T (3) Cv – T (3) Gp – T (3) Np – T (3)	Palmer and Maloney (1955)
Phenylmercuric nitrate	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Comment same as above, including data cited.	Palmer and Maloney (1955)
n-phenyl-naphthyl-amine	*Daphnia magna*	BSA	–	4.4 (K2)	a	An attempt was made to correlate the biological action with the chemical reactivity of selected chemical substances. Results indicated a considerable correlation between the aquarium fish toxicity and antiautocatalytic potency of the chemicals in marked contrast to their toxicity on systemic administration.	Sollman (1949)
Phenylthiourea	*Microcystis aeruginosa*	L	–	50 (K)	a	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
Phloroglucinol	*Daphnia magna*	BSA	–	630 (K2)	a	An attempt was made to correlate the biological action with the chemical reactivity of selected chemical substances. Results indicated a considerable correlation between the aquarium fish toxicity and antiautocatalytic potency of the chemicals in marked contrast to their toxicity on systemic administration.	Sollman (1949)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Phosphoric acid	*Gambusia affinis*	BSA	–	138 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Phosphorus	*Lepomis macrochirus*	BSA	–	0.105 (T2A) 0.053 (T3A) 0.025 (T7A)	a c d e f g h i j k n o	Colloidal phosphorus compounds were removed by filtration, so that the effect of elemental phosphate toxicity was studied.	Isom (1960)
o-phthalic anhydride	*Pimephales promelas*	BSA	–	>56 (T4A)	a c d e f	o-phthalic anhydride is very slightly soluble in water.	Pickering and Henderson (1966)
Picric acid	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – NT Ma – NT So – NT Cv – NT Gp – NT Np – NT	Palmer and Maloney (1955)
Polyethylene glycol	Sewage microorganisms	BOD	–	(O)	–	The chemical was studied as to how low levels (ppm) may affect BOD in domestic sewage. This compound was not toxic to sewage microorganisms. No concentration of the chemical was given. Apparently this glycol is biochemically inert because it did not respond even to acclimated seed.	Oberton and Stack (1957)
Polyoxy-ethylene ester	*Pimephales promelas* (juveniles)	BSA	–	(S) 37-42 (T1-4A) (H) 38-56 (T1-4A)	a c d f	Syndets and soaps were of nearly equal toxicity in soft water (S) but syndets were approximately 40X more toxic than soap in hard water (H).	Henderson, et al (1959)
Potassium azide	*Procambarus clarki* *Lepomis macrochirus*	BSA	–	1 (K1)* 2 (K1)** <1.5 (T1A)* <1.8 (T1A)** *Technical formulation **Granular	a	In general, when mud was added to the tank the toxicity of the chemical decreased.	Hughes (1966)
Potassium azide	*Pteronarcys californica* (naiads)	BSA	–	0.008 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Potassium chloride	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, possible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compares this work with earlier work, and lists an extensive bibliography. In 0.214N solution, fish survived 69 minutes.	Powers (1918)

Potassium chloride	*Daphnia magna*	BSA	–	373 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Potassium chloride	*Daphnia magna*	BSA	–	432 (O)	a	Lake Erie water was used as diluent. Toxicity given as threshold concentration producing immobilization for exposure periods of 64 hr.	Anderson (1948)
Potassium chloride	*Lepomis macrochirus*	BSA	–	2,010 (T4A)	a d e f	This paper reports the LD_{50} in 96 hours for 8 common inorganic salts. A synthetic dilution water of controlled hardness was prepared for use in the experiments. Among other variables, specific conductivity, as mhos at 20 C, was measured.	Trama (1954)
Potassium chloride	*Gambusia affinis*	BSA	–	4,200 (T2A)	a c d e f	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Potassium chloride	*Biomorpholaria a. alexandrina* *Bulinus truncatus*	BSA	–	1800 (K1A) 1200 (K1A)	a	The degree of tolerance for vector snails of biharziasis chemicals is somewhat dependent upon temperature. The temperature at which (K1A) occurred was 26 C.	Goher and El-Gindy (1961)
Potassium chloride	*Daphnia magna* *Lepomis macrochirus* *Lymnaea* sp	BSA	–	679 (T1A) 5,500 (T1A) 1,941 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Potassium chloride	*Nitzschia linearis* *Lepomis macrochirus* *Physa heterostropha*	BSA	–	1,337 (T5A) 940 (T4A) 2,010 (T4A)	a c e	The purpose of this experiment was to determine whether there was a constant relationship between the responses of these organisms. From the data presented, there was no apparent relationship of this type. Therefore the authors advise that bioassays on at least 3 components of the food web be made in any situation.	Patrick, et al (1968)
Potassium chromate	*Salmo gairdnerii*	BSA	–	(O) 2000 ppm (42.0 min) 1000 ppm (79 min) 20 ppm (3580 min)	a c e f	Tap or distilled water used as diluent. Toxicity defined as the avg. time when the fish lost equilibrium when exposed to the test chemical (ppm Cr).	Grindley (1946)
Potassium chromate	*Lepomis macrochirus*	BCFA	–	450 (T4A) small 630 (B4A) medium 5.50 (T4A) large	a c e f	Test water was composed of distilled water with CP grade chemicals and was aerated throughout the 96-hour exposure period. Beginning pH was 7.9 to 8.6, pH after four days was 7.0 to 7.94.	Cairns and Scheier (1955)
Potassium chromate	*Gambusia affinis*	BSA	–	480 (T2A)	a c d e g	The effect of turbidity on the toxicity on the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Potassium chromate	Sewage organisms	BOD	–	10.5 (O)	–	Various metal salts were studied in relation to how they affected the BOD of both raw and treated sewage as well as how they affected the processing of sewage in the treatment plant. BOD was used as the parameter to measure the effect of the chemical. The chemical concentration cited is the ppm required to reduce the BOD values by 50%. This chemical was tested in an unbuffered system.	Sheets (1957)
Potassium chromate	*Micropterus salmoides*	BSA	–	195 (T2A)	a c d e	The mechanism for poisoning is discussed. Exposure to chromium caused severe pathological change in the intestine immediately posterior to the pyloric caeca that in all probability completely destroyed its digestive function.	Fromm and Schiffman (1958)
Potassium chromate	*Lepomis macrochirus*	BSA	–	550 (T4A)	a c d e i	A "control" was prepared by adding required chemicals to distilled water, and this was constantly aerated. Data reported are for larger fish, app 14-24 cm in length. Data for smaller fish are also in the report.	Cairns and Scheier (1959)
Potassium chromate	*Salmo gairdnerii*	BSA	–	100 (T1)	a c d g	Trout exposed to 20 ppm chromium had a mean hematocrit of 43.8, as compared to unexposed trout of 31.8. Additional data are presented.	Schiffman and Fromm (1959)
Potassium chromate	*Pimephales promelas*	BSA	–	(S) 45.6 (T4A)	c d e f	(S) Soft water Values are expressed as mg/l of chromium.	Pickering and Henderson (1965)
Potassium chromate	*Nitzschia linearis* *Physa heterostropha* *Lepomis macrochirus*	BSA	–	7.8 (T5A) 16.8 (T4A) 168.8 (T4A)	a c e	The purpose of this experiment was to determine whether there was a constant relationship between the responses of these organisms. From the data presented there was no apparent relationship of this type. Therefore the authors advise that bioassays on at least 3 components of the food web be made in any situation.	Patrick, et al (1968)
Potassium cuprocyanide	*Rhinichthys atratulus*	BCFA	–	0.38, 0.47 and 0.71 (T1A)	a c e	The three values given are for cyanide to copper ratios of 4.0, 3.7, and 3.0, respectively.	Lipschuetz and Cooper (1955)
Potassium cyanide (as CN)	Rainbow trout (yearling)	BCFA	–	0.14 (K-160 min)	a c e	Toxicity was determined in terms of survival time. Acclimatization of fish to test conditions and fish size was studied.	Herbert and Merkens (1952)
Potassium cyanide	*Microcystis aeruginosa*	L	–	90 (K)	a	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
Potassium cyanide	Rainbow trout (yearling)	BSA	–	0.105-0.155 (O)	a c e	Tap water was used as diluent. Study related oxygen concentration effect to cyanide toxicity. As an example, control fish in 1.11 ppm O_2 were affected in 18 min; at 0.105 ppm CN^-, fish survived only 3.3 min at 10% O_2 concentration.	Downing (1954)

Potassium cyanide	*Salmo gairdnerii*	BCFA	–	(O)	a	Time-survival curves are plotted for seven concentrations of cyanide, from 0.14 to 10 ppm. At 10 ppm, all fish died in less than 3 minutes. At 0.14 ppm all fish died in 165 minutes.	Herbert and Downing (1955)
Potassium cyanide	*Rhinichthys atratulus meleagris*	BCFA	–	0.22 (T1A)	a c e	This report contains a comparison of the toxicities of KCN and potassium cuprocyanide of three different compositions. Four-hour median tolerance limits are also given.	Lipschuetz and Cooper (1955)
Potassium cyanide	*Lepomis macrochirus*	BCFA	–	0.55 (T46) small 0.45 (T46) medium 0.57 (T46) large	a c e f	Test water was composed of distilled water with CP grade chemicals and was aerated throughout the 96-hour exposure period. The cyanide ion concentration was controlled.	Cairns and Scheier (1955)
Potassium cyanide	*Gambusia affinis*	BSA	–	1.6 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Potassium cyanide	*Lepomis macrochirus*	BSA	–	0.45 (T4A)	a c e	Increase in temperature seemed to increase toxicity of this chemical. Low dissolved oxygen reduced toxicity of some chemicals in this study. Toxicity values may be 20% higher in hard versus soft water.	Cairns (1957)
Potassium cyanide	*Lepomis macrochirus* *Physa heterostropha*	BSA	–	(N) 0.45 (T4A) (L) 0.12 (T4A) (N) 1.08 (T4A) (L) 0.48 (T4A)	a e	Modified Chu No. 14 test medium was used. Toxicity is given both for "normal" O_2 (5-9 ppm), (N), and with "low" O_2 (2 ppm DO), (L). High and low threshold concentration and concentration percent of survival are also presented.	Cairns and Scheier (1958)
Potassium cyanide	Sewage organisms	BOD	–	15 (TC_{50})	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Potassium cyanide (as CN^-)	*Brachydanio rerio* (adults) (eggs) *Lepomis macrochirus*	BSA	–	 0.49 (T2A) 117 (T2A) 0.16 (T2A)	a c d e f	The test dilutions were made up from distilled water and ACS grade chemicals. Temperature was held at 24 C and the solution was aerated to maintain a dissolved oxygen content of 5-9 ppm.	Cairns, et al (1965)
Potassium cyanide	*Lepomis macrochirus* *Physa heterostropha*	BSA	–	0.45 (T4A) 0.12 (T4A) 1.08 (T4A) 0.48 (T4A)	a e	Normal oxygen content in water. Low oxygen content in water. Normal oxygen content in water Low oxygen content in water.	Cairns (1965)
Potassium cyanide	*Lepomis macrochirus*	BSA	–	0.57 (T4A)	a c d e i	A "control" was prepared by adding required chemicals to distilled water, and this was constantly aerated. Data reported are for larger fish, app 14-24 cm in length. Data for smaller fish are also in the report.	Cairns and Scheier (1959)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Potassium cyanide	*Lepomis macrochirus*	BSA	–	0.43 (T4A)	a c d e f	The experiments were conducted in a water of controlled chemical composition. The TL_m concentration of KCN was slightly affected by increased temperature (more toxic at 30 C than at 18 C), but not by water hardness.	Cairns and Scheier (1963)
Potassium cyanide	*Rasbora heteromorpha*	BSA	–	0.072 (O)	–	For many toxins the rate of mortality is found to be a linear function of the logarithm of the concentration of the poison; whereas the comparable relation between the logarithms of the survival time and the concentration is nonlinear. The linear function can be exploited to provide comparatively simple methods of estimating long-term survival concentrations. An application of this is suggested for defining realistic standards of toxicity. At the concentration reported, there was a 20 percent mortality in 7 days.	Abram (1964)
Potassium cyanide	*Daphnia magna*	BSA	–	2 (T1A) 0.7 (T3A) 0.4 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
	Lymnaea sp (eggs)			796 (T1A) 147 (T3A) 130 (T4A)			
Potassium cyanide as (CN^-)	*Hydropsyche* *Stenonema*	BSA	–	2.0 (T2A) 0.5 (T2A)	a	Soft water used as diluent water.	Roback (1965)
Potassium dichromate	*Daphnia magna*	BSA	–	<0.6 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Potassium dichromate	*Salmo gairdnerii*	BSA	–	2000 ppm – 23.8 min 1000 ppm – 54.6 min 200 ppm – 188 min 20 ppm – 4342 min	a c e f	Tap or distilled water used as diluent. Toxicity defined as the avg time when the fish lost equilibrium when exposed to the test chemical (ppm Cr).	Grindley (1946)
Potassium dichromate	*Lepomis macrochirus*	BCFA	–	320 (T4A)	a c e f	Test water was composed of distilled water with CP grade chemicals and was aerated throughout the 96-hour exposure period. The pH of the test water was about 6.2, which was determined by the concentration of the test chemical.	Cairns and Scheier (1958)
Potassium dichromate	*Gambusia affinis*	BSA	–	320 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)

Potassium dichromate	*Lepomis macrochirus*	BSA	–	320 (T4A)	a c e	Increase in temperature seemed to increase toxicity of this chemical. Low dissolved oxygen reduced toxicity of some chemicals in this study. Toxicity values may be 20% higher in hard versus soft water.	Cairns (1957)
Potassium dichromate	*Lepomis macrochirus*	BSA	–	(N) 320 (T4A) (L) 320 (T4A)	a e	Modified Chu No. 14 test medium was used. Toxicity is given both for "normal" O_2 (5-9 ppm), (N), and with "low" O_2 (2 ppm DO), (L). High and low threshold concentration and concentration percent of survival are also presented.	Cairns and Scheier (1958)
Potassium dichromate	*Lepomis macrochirus*	BSA	–	320-384 (T4A)	a c d e f	The concentration of $K_2Cr_2O_7$ which resulted in 50 percent kill in 96 hours was 320 ppm in soft water at both 18 and 30 C, 382 ppm in hard water at 18 C, and 369 ppm in hard water at 30 C.	Cairns and Scheier (1959)
Potassium dichromate	*Lepomis macrochirus*	BSA	–	320 (T4A)	a c d e i	A "control" was prepared by adding required chemicals to distilled water, and this was constantly aerated. Data reported are for larger fish, app 14-24 cm in length. Data for smaller fish are also in the report.	Cairns and Scheier (1959)
Potassium dichromate	Sewage organisms	BOD	–	17.0 (TC_{50})	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Potassium dichromate	*Hydropsyche* *Stenonema*	BSA	–	28.0 (T2A) 3.5 (T2A)	a	Soft water used as diluent water.	Roback (1965)
Potassium dichromate	*Lepomis macrochirus*	BSA	–	320 (T4A) 320 (T4A)	a e	Normal oxygen content of water. Low oxygen content of water.	Cairns (1965)
Potassium dichromate	*Carassius carassius* *Daphnia magna* *Lepomis macrochirus*	BSA	–	705 (T1A) 0.4 (T4A) 739 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Potassium dichromate	*Brachydanio rerio* (adults) (eggs) *Lepomis macrochirus*	BSA	–	 180 (T2A) 1500 (T2A) 440 (T2A)	a c d e f	The test dilutions were made up from distilled water and ACS grade chemicals. Temperature was held at 24 C and the solution was aerated to maintain a dissolved oxygen content of 5-9 ppm.	Cairns, et al (1965)
Potassium dichromate	*Pimephales promelas* *Lepomis macrochirus* *Carassius auratus* *Lebistes reticulatus*	BSA	–	(S) 17.6 (T4A) (H) 27.3 (T4A) (S) 118.0 (T4A) (H) 133.0 (T4A) (S) 37.5 (T4A) (S) 30.0 (T4A)	c d e f	(S) Soft water (H) Hard water Values are expressed as mg/l of chromium.	Pickering and Henderson (1965)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Potassium dichromate	*Nitzschia linearis* *Physa heterostropha* *Lepomis macrochirus*	BSA	–	0.208 (T4A) 17.3 (T4A) 113.0 (T4A)	a c e	The purpose of this experiment was to determine whether there was a constant relationship between the responses of these organisms. From the data presented, there was no apparent relationship of this type. Therefore the authors advise that bioassays on at least 3 components of the food web be made in any situation.	Patrick, et al (1968)
Potassium ferricyanide	*Daphnia magna*	BSA	–	905 (T1A) 549 (T2A) 0.6 (T3A) 0.1 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Potassium hydroxide	*Gambusia affinis*	BSA	–	80 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Potassium hydroxide	*Biomorpholaria a. alexandrina* *Bulinus truncatus* *Lymnaea caillaudi*	BSA	–	500 (K1A) 300 (K1A) 150 (K1A)	a	The degree of tolerance for vector snails of biharziasis to chemicals is somewhat dependent upon temperature. The temperature at which (K1A) occurred was 27 C.	Gohar and El-Gindy (1961)
Potassium nitrate	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, possible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compares this work with earlier work, and lists an extensive bibliography. In 0.00002N solution, fish survived 2135 minutes.	Powers (1918)
Potassium nitrate	*Gasterosteus aculeatus*	BSA	–	50 (K10)	–	Solutions were made up in tap water. 3.0 to 5.0 cm stickleback fish were used as experimental animals. This paper points out that there is a marked relationship between the toxicity of the metals and their solution pressures. Those with low solution pressures were the most toxic.	Jones (1939)
Potassium nitrate	*Lepomis macrochirus*	BSA	–	3,000 (T4A)	a d e f	This paper reports the LD_{50} in 96 hours for 8 common inorganic salts. A synthetic dilution water of controlled hardness was prepared for use in the experiments. Among other variables, specific conductivity, as mhos at 20 C, was measured.	Trama (1954)
Potassium nitrate	*Gambusia affinis*	BSA	–	224 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Potassium nitrate	*Biomorpholaria a. alexandrina* *Bulinus truncatus*	BSA	–	2600 (K1A) 1800 (K1A)	a	The degree of tolerance for vector snails of biharziasis to chemicals is somewhat dependent upon temperature. The temperature at which (K1A) occurred was 28 C for *Bulinus* and 25 C for *Biomorpholaria*.	Gohar and El-Gindy (1961)

Potassium nitrate	*Daphnia magna*	BSA	–	900 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
	Lepomis macrochirus			5,500 (T1A)			
	Lymnaea sp (eggs)			1,941 (T1A)			
Potassium permangante	*Daphnia magna*	BSA	–	0.63 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Potassium permanganate	*Gambusia affinis*	BSA	–	12 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Potassium permanganate	Channel catfish (fingerlings)	BSA	–	<3.2 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Potassium permanganate	*Lepomis macrochirus*	BSA	–	4.2 (T1,2,4A)	–	The values given are for a laboratory study. However, when concentrations as high as 32 ppm were applied in a pond, no fish deaths occurred.	Kemp, et al (1966)
	Semotilus atromaculatus			3.7 (T4A)			
Potassium permanganate	Blue-green algae *Cylindrospermum* *Anabaena* *Anacystis* *Calothrix* *Nostoc* *Oscillatoria* *Plectonema* Green algae *Ankistrodesmus* *Chlorella* *Closterium* *Oocystis* Green algae *Scenedesmus* *Stigeoclonium* *Zygnema* Green flagellate and yellow algae *Chalmydomonas* *Pandorina* *Tribonema* *Gomphonema* *Navicula* *Nitzchia*	L	–	4.0-8.0 (O)	–	$KMnO_4$ was toxic or partially toxic at the indicated concentrations to blue-green and green algae. A concentration of 8.0 ppm was usually required to control green, flagellate, and yellow algae.	Kemp, et al (1966)
Potassium phosphate	*Gambusia affinis*	BSA	–	750 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Potassium sulfate	*Lepomis macrochirus*	BSA	–	3,550 (T4A)	a d e f	This paper reports the LD_{50} in 96 hours for 8 common inorganic salts. A synthetic dilution water of controlled hardness was prepared for use in the experiments. Among other variables, specific conductivity, as mhos at 20 C, was measured.	Trama (1954)
Potassium tellurite	*Carassius auratus*	BSA	–	(O)	a c	A 0.5% solution in water prolonged the mortality of sperm for at least 5 minutes in all samples tested. A 0.5% solution in frog Ringer's produced similar mortility patterns but average activity was lower after 10 minutes than in water solution.	Fribourgh (1965)
Propion-hydroxamic acid	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
Propionic acid	*Culex* sp (larvae)	BSA	–	1000 (T2A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
	Daphnia magna			50 (T2A)			
	Lepomis macrochirus			188 (T1A)			
n-propyl alcohol	*Semotilus atromaculatus*	BSA	–	200 to 500 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hrs. and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
Propylene phenoxetol	*Pleuronectes platessa*	BSA	–	(O)	a	Fish were tested at 6.5 C in aquariums of 3-liter capacity. At 0.05% solution, the fish were able to survive if removed to fresh water within 1 hour after exposure. At 15 C and 0.005% solution, the fish took 2 hours to become completely anesthetized and were unable to recover after 3 hours of exposure. At 15 C and 0.025% solution, the fish were not able to survive if not removed within 1 hour. The chemical can be used as an anesthetic for periods of up to 1 hour when a solution of 0.01-0.025% is used.	Bagenal (1963)
n-propyl-N,N-di-n-propyl thiol-carbamate		BSA	–		a	Experiments were conducted in standing water. Results were rated on a scale of 0 to 10, 0 standing for no toxic effect and 10 signifying a complete kill. Evaluation was based on visual observation of the plant response at weekly intervals for 4 weeks.	Frank, et al (1961)
	Elodea canadensis			5 (O) 100 (O)		No toxic effect. Injury rating of 9.4.	
	Potamogeton nodosus			5 (O) 100 (O)		No toxic effect. Injury rating of 7.4	
	Potamogeton pectinatus			5 (O) 100 (O)		No toxic effect. Injury rating of 8.3	

Pyridine	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, possible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compares this work with earlier work, and lists an extensive bibliography. In a concentration of 3.187 cc per liter, fish survived 180 minutes.	Powers (1918)
Pyridine	*Gambusia affinis*	BSA	–	1,350 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Pyridine	*Daphnia magna*	BSA	–	2,114 (T1A) 944 (T2A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Pyridyl-mercuric acetate	Rainbow trout	FL	Wash.	2.0 (O)	–	After the first treatment with the chemical the ponds were partially emptied, flushed, and refilled. After a second treatment, one pond showed a "catastrophic mortality". The authors were unable to explain this unusual phenomenon.	Foster and Olson (1951)
Pyridyl-mercuric acetate (tech.)	*Salmo gairdnerii*	BSA	–	10 (K 17% – 1 hr) 47 F 10 (K 50% – 1 hr) 56 F 5 (K 1-1/2% – 1 hr) 47 F 5 (K 18% – 1 hr) 56 F 2.5 (K 0% – 1 hr) 47 F 2.5 (K 1% – 1 hr) 56 F	a	Temp concentration data presented on groups of 200 fingerlings. Brook and Brown trout not affected by the test conc. of 10, 5, and 2.5 ppm at either 47 F or 56 F for 1 hr.	Rodgers, et al (1951)
Pyridyl-mercuric acetate (80% active)	*Ictalurus punctatus*	BSA	–	5.0 (K2) 3.8 (T2A)	a c f i	The experiment was conducted at 75 C.	Clemens and Sneed (1958)
Pyridyl-mercuric acetate	Channel catfish (fingerlings)	BSA	–	4.12 (T2A) 2.81 0.49 2.81 (T3A) 1.81 <.37 2.43 (T4A) <.37 <.37	a	The toxicity of this compound increased as the temperature was increased. In the data shown, the values for each T level is for temperatures of 10, 16.5 and 24 centigrade. These values were selected from a table presenting concentrations for T levels from one to 153 hours. Fish of different ages were also studied.	Clemens and Sneed (1959)
Pyridyl-mercuric acetate	Channel catfish (fingerlings)	BSA	–	3.8 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Pyrocatechol	*Daphnia magna*	BSA	–	14 (K2)	a	An attempt was made to correlate the biological action with the chemical reactivity of selected chemical substances. Results indicated a considerable correlation between the aquarium fish toxicity and antiautocatalytic potency of the chemicals in marked contrast to their toxicity on systemic administration.	Sollman (1949)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Pyrogallol	*Daphnia magna*	BSA	–	18 (K2)	a	An attempt was made to correlate the biological action with the chemical reactivity of selected chemical substances. Results indicated a considerable correlation between the aquarium fish toxicity and antiautocatalytic potency of the chemicals in marked contrast to their toxicity on systemic administration.	Sollman (1949)
Quinacrine hydro-chloride	*Salmo gairdneri*	BSA	–	17.2 (T2A)	a f	Variance and the 95-percent confidence interval (C.I.) were also determined.	Willford (1966)
	Salmo trutta			230 (T2A)			
	Salvelinus fontinalis			230 (T2A)			
	Salvelinus namaycush			21.0 (T2A)			
	Ictalurus punctatus			70.0 (T2A)			
	Lepomis macrochirus			79.0 (T2A)			
Quinine sulphate	Channel catfish (fingerlings)	BSA	–	42 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Quinhydrone	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
Quinone	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	Comment same as above.	Fitzgerald, et al (1952)
Resorcinol	*Daphnia magna*	BSA	–	56.4 (K2)	a	An attempt was made to correlate the biological action with the chemical reactivity of selected chemical substances. Results indicated a considerable correlation between the aquarium fish toxicity and antiautocatalytic potency of the chemicals in marked contrast to their toxicity on systemic administration.	Sollman (1949)
Salicylaldehyde	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – PT (3) Ma – PT (3) So – PT (3) Cv – PT (3) Gp – T (3), PT (21) Np – T (3), PT (21)	Palmer and Maloney (1955)

Salicylic acid	Sewage organisms	BOD	–	110 (TC_{50})	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Selenium	Black bullhead Bluegill Channel catfish Largemouth bass Rainbow trout White crappie Yellow walleye	FL	Sweitzer Lake, Colo.	–	a c	It was tentatively concluded on the basis of the available data that fish kill probably resulted from the toxic effects of selenium, possibly acting in synergism with other ions such as uranium or zinc. Arsenic was also found in the lake. Samples of flora and fauna of the lake were analyzed and found to contain greater than 300 ppm selenium. It was believed that selenium is passed up the food chain to the fish which accumulated the element in lethal concentrations.	Barnhart (1958)
Silver, colloidal	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – PT (3) Ma – PT (14) So – NT Cv – NT Gp – NT Np – NT	Palmer and Maloney (1955)
Silver, colloidal, (33 percent silver nitrate)	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Comment same as above except that: Cl – T (3) Ma – T (3) So – T (3) Cv – T (3) Gp – T (3) Np – T (3)	Palmer and Maloney (1955)

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Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Silver	*Lebistes reticulatus*	BSA	–	0.01 (K)	a c e	It is assumed in this experiment that the cations considered are toxic because they combine with an essential sulfhydryl group attached to a key enzyme. This treatment indicates that the metals which form the most insoluble sulfides are the most toxic. The log of the concentration of the metal ion is plotted against the log of the solubility product constant of the metal sulfide — a treatment that does not lend itself to tabulation. The cation toxicity cited is only an approximate concentration interpolated from a graph. Time of death was not specified.	Shaw and Grushkin (1967)
	Bufo valliceps (tadpoles)			0.1 (K)			
	Daphnia magna			0.1 (K)			
Silver-cynaide complex	*Lepomis macrochirus* (juveniles)	BSA	–	(K <1.0)	a c d f p	With 10 ppm as cyanide content, the median resistance time varied from 391 to 789 minutes.	Doudoroff, et al (1966)
Silver nitrate	*Gasterosteus aculeatus*	BSA	–	0.003 (K10)	–	Solutions were made up in tap water. 3.0 to 5.0 cm stickleback fish were used as experimental animals. This paper points out that there is a marked relationship between the toxicity of the metals and their solution pressures. Those with low solution pressures were the most toxic.	Jones (1939)
Silver nitrate	*Daphnia magna*	BSA	–	0.0051 (O)	a	Lake Erie water was used as diluent. Toxicity given as threshold concentration producing immobilization for exposure periods of 64 hours.	Anderson (1948)
Silver nitrate	Sewage organisms	BOD	–	0.3 (O)	–	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 6.6. Solutions were renewed every 12 hours.	Sheets (1957)
Silver sulfate	*Balanus balanoides*	BSA	–	0.4 (O)	–	The concentration listed was lethal to 90% of adult barnacles in 2 days.	Clarke (1947)
Sodium acetate	*Polycelis nigra*	BSA	–	0.15 M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 7.2. Solutions were renewed every 12 hours.	Jones (1941)
Sodium acetate	*Daphnia magna*	BSA	–	<5800 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water. This salt may be toxic only when the concentration is great enough to exert an unfavorable osmotic effect.	Anderson (1946)
Sodium acetate	*Lepomis macrochirus*	BSA	–	5,000 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
	Culex sp. (larvae)			7,500 (T1A)			
Sodium aluminate	*Gambusia affinis*	BSA	–	126 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)

Sodium anthra-quinone alpha-sulfonate	*Daphnia magna* *Lymnaea* sp (eggs)	BSA	–	12 (T1A) 186 (T1-4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Sodium anthra-quinone-a-sulfonate	*Daphnia magna*	BSA	–	(O)	a c	Assay water was not characterized chemically or otherwise described. The pH at 100 percent toxicity was 7.1. The 100-hr threshold was 12%, with 0 percent toxicity at 10% and 100 percent toxicity at 30%.	Freeman (1953)
Sodium arsenate	*Polycelis nigra*	BSA	–	0.0048 M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 7.2. Solutions were renewed every 12 hours.	Jones (1941)
Sodium arsenate (as As_2O_3)	Smallmouth black bass Largemouth black bass Bluegill sunfish White crappie *Potomogeton crispus* *P. foliosus* *Najas flexilis* *Anarchis canadensis* *Nymphea* sp *Scirpus validus* *Chara* sp *Hydrodictyon* sp *Oedogonium* sp *Cladophora* sp	FL	Leetown, Va.	5.0 (O)	d	Treatment of a series of ponds resulted in control of *P. crispus, P. foliosus, N. flexilis,* and *A. canadensis. Nymphea* sp, *S. validus,* and *Chara* sp were not controlled. Scum algae (*Hydrodictyon* sp, *Oedogonium* sp, and *Cladophera* sp) in solid mats were effectively destroyed by the arsenate. Decomposing vegetation stimulated growth of more desirable algae. No fish mortality occurred due to toxic effect of chemical, but some fish suffocated due to decaying vegetation.	Surber and Everhart (1950)
Sodium arsenate	*Daphnia magna*	BSA	–	31 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Sodium arsenate	*Phoxinus phoxinus*	BSA	–	2970 ppm (205 min) 820 ppm (467 min) 234 ppm (951 min)	a c e f	Tap or distilled water used as diluent. Toxicity defined as the avg time when the fish lost equilibrium when exposed to the test chemical (ppm As).	Grindley (1946)
Sodium arsenate	*Daphnia magna*	BSA	–	<20 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water. This salt may be toxic only when the concentration is great enough to exert an unfavorable osmotic effect.	Anderson (1946)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Sodium arsenate	Sewage organisms	BOD	–	>100 (TC_{50})	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Sodium arsenite or arsenious oxide	*Caenis* sp	BSA	–	3.0 (K)	a	River water was used as test media with room temperature and natural sunlight as environmental conditions. Considerable additional data are presented.	Surber and Meeham (1931)
	Callibaetis sp			4.0 (K)			
	Libellula sp			14.0 (56% survival)			
	Ischnura verticalis			11.2 (85% survival)			
	Chironomidae			2.96 (83% survival)			
	Asellus communis			21 (81% survival)			
	Hydracarina sp			10.5 (94% survival)			
	Hyalella knickerbockeri			5.88 (30% survival)			
	Colpidium sp			3.5 (100% survival)			
	Paramecium sp			1.75 (plasmolysis but no kill)			
	Stylonichia sp						
	Spirogyra sp						
Sodium arsenite	*Phoxinus phoxinus*	BSA	–	953 ppm (54.6 min) 290 ppm (186 min) 17.8 ppm (2174 min)	a c e f	Tap or distilled water used as diluent. Toxicity defined as the avg time when the fish lost equilibrium when exposed to the test chemical (ppm As).	Grindley (1946)
Sodium arsenite	*Daphnia magna*	BSA	–	9.1 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water. This salt may be toxic only when the concentration is great enough to exert an unfavorable osmotic effect.	Anderson (1946)
Sodium arsenite	*Notropsis hudsonius*	BSA	–	45 (T1A) 29 (T2A) 27 (T3A)	a c d e	Some of the fish were not killed in 72 hours by the higher doses of arsenic (30-35 ppm), had extensive damage to the fins, while others had scale damage, severe diarrhea, heavy breathing and hemorrhaging of the body areas around the caudal, dorsal, and ventral fins.	Boschetti and McLoughlin (1957)

Sodium arsenite	*Pithophora* sp *Hydrodictyon* sp Bottom organisms *Lepomis macrochirus* Microcrustacea Rotifers	FL	Ala. ponds	4.0 (O) 4.0 (O) 4.0 (O)	–	The purpose of this experiment was to determine the effectiveness of sodium arsenite as a control agent for *Pithophora* and to determine the effects of repeated applications of 4 and 8 ppm arsenious oxide as sodium arsenite on bottom organisms and fish production in treated ponds. *Pithophora* was controlled by one or more applications of sodium arsenite at a concentration of 4.0 ppm arsenious oxide. Best results were obtained when sodium arsenite was applied while the alga was in an active growing stage. The alga *Hydrodictyon* was also controlled at 4.0 ppm. The applications of 4 ppm applied 1 month apart reduced the number of bottom organisms an average of 34 percent and reduced bluegill production an average of 42 percent as compared with those of the controlled ponds.	Lawrence (1958)
Sodium arsenite	*Notemigonus crysoleucas* *Pimephales promelas* *Lepomis macrochirus*	FPCH	N.Y.	4.0 (S23) 4.0 (S23) 4.0 (S23)	a c d	Conventional farm ponds were used having an average surface area of 0.3 acre and a maximum depth of 7-9 ft. Toxicity (in ppm) to fish as maximum safe concentration (S) for 23 days was determined. Concentration of 0.5 ppm was required to control algae.	Eipper (1959)
Sodium arsenite	Channel catfish (fingerlings)	BSA	–	47.9 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Sodium arsenite	*Lepomis* sp	FL	Ponds in Ala.	(O)	–	Fish from ponds treated with sodium arsenite were analyzed for arsenic when the concentration in the water had declined to less than 1.0 ppm arsenious oxide. Bluegill sunfish analyzed for arsenic were recovered by seining when the arsenious oxide concentration in the pond water had declined to less than 1.0 ppm. Arsenic in the digestive tract of bluegills from the ponds ranged from 2.1 to 6.6 ppm arsenious oxide (wet weight). However, no detectible arsenic or only a trace amount was found in the tissue of the digestive tract, liver, or muscle.	Dupree (1960)
Sodium arsenite	Calico fish	FL	N.Y.	(O)	–	Fish were analyzed for arsenic, before and after the lakes were treated with this herbicide. No differences in residues were noted.	Ullmann (1961)
50-51 (sodium arsenite)	Water Hyssop Parrot's Feather Bladderwort	FL	Lakes in Fla.	(O) (O) (O)	–	A concentration of 10.0 ppm controlled the indicated species.	Phillippy (1961)
50-52 (sodium arsenite)	Water Hyssop Parrot's Feather Bladderwort	FL	Lakes in Fla.	(O) (O) (O)	–	Comment same as above.	Phillippy (1961)
Sodium arsenite (tech.)	Rainbow trout Bluegill	BSA	–	26 (T4A) 30 (T4A)	a	This is an estimated LC_{50} value at temperatures from 55 to 75 F.	Cope (1965)

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Chemical	Organism	Bioassay or Field Study$^{(1)}$	Field Location$^{(2)}$	Toxicity, Active Ingredient ppm$^{(3)}$	Experimental Variables Controlled or Noted$^{(4)}$	Comments	Reference (Year)
Sodium arsenite	Filamentous algae	FL	N.Y.		a c		Cowell (1965)
	Cladophora			4 (K)		Complete decomposition in about 2 weeks.	
	Spirogyra			4 (K)		Complete decomposition in about 2 weeks.	
	Zygnema			4 (K)		Complete decomposition in about 2 weeks.	
	Submerged plants						
	Chara			(O)		Sodium arsenite, 4 ppm, did not cause any kill.	
	Potamogeton			(O)		Sodium arsenite, 4 ppm, caused 95% kill. Decomposition occurred in about 1 month.	
	Emergent plants						
	Alisma			(O)		Sodium arsenite, 4 ppm, caused 15% kill.	
	Sagittaria			(O)		Sodium arsenite, 4 ppm, did not cause any kill.	
	Zooplankton			(O)		Applications of 4 ppm sodium arsenite produced significant reduction.	
Sodium arsenite	*Pteronarcys* sp (nymphs)	BSA	–	45 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Sodium arsenite	*Salmo gairdnerii*	FL	La Cross, Wis.	25 (T4A)	a c f i m	The herbicide used was a commercial formulation containing 40 percent sodium arsenite by weight. Substantial residues of arsenic were found in the water, bottom soil, and throughout the organs and flesh of the bluegills at the termination of the experiment. Treatments totaling 4.0 ppm or more resulted in reduced numbers of bottom fauna, and a concentration of 1.2 ppm of the chemical controlled rotifers.	Gilderhus (1966)
	Carassius auratus			34 (T4A)			
	Lepomis macrochirus			35 (T4A)			
Sodium arsenite	*Daphnia magna*	BSA	–	6.5 (5.7-7.3) (O)	a c d i q	Toxicity, in terms of median immobilization concentration (IC_{50}), is presented for *Daphnia;* median lethal concentration (LC_{50}) values for rainbow trout and bluegill are reported.	Crosby and Tucker (1966)
	Rainbow trout			60 (O) 60 (O)			
	Bluegill			44 (O)			
Sodium arsenite	*Salmo gairdneri*	BSA	–	36.5 (T2A)	a	This paper reports acute toxicity of a number of compounds, and discusses subacute mortality as well. Effects on reproduction and behavior are also discussed. Data presented as EC_{50}.	Cope (1966)
	Lepomis macrochirus			44.0 (T2A)			
	Pteronarcys californicus			80.0 (T2A)			
	Daphnia pulex			1.8 (T2A)			
	Simocephalus serrulatus			1.4 (T2A)			
Sodium arsenite	*Simocephalus serrulatus*	BSA	–	1.4 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
	Daphnia pulex			1.8 (SB)			

Sodium arsenite	Blue-green algae *Cylindrospermum* *Anabaena* *Anacystis* *Calothrix* *Nostoc* *Oscillatoria* *Plectonema* Green algae *Ankistrodesmus* *Chlorella* *Closterium* *Oocystis* Green algae *Scenedesmus* *Stigeoclonium* *Zygnema* Green flagellate and yellow algae *Chalmydomonas* *Pandorina* *Tribonema* *Gomphonema* *Navicula* *Nitzchia*	L	–	2.0 (O)	–	$NaAsO_2$ was generally nontoxic or only partially toxic briefly for all algae species. Growth of *Cylindrospermum* and *Nitzchia* was apparently stimulated. This compound was the least effective of four evaluated as algicides.	Kemp, et al (1966)
Sodium arsenite	*Lepomis macrochirus*	BSA	–	0.7 (T1A)	a b e	This report is a simple and straightforward determination of a median tolerable limit for a selected group of herbicides.	Hughes and Davis (1967)
Sodium arsenite (tech.)	*Pteronarcys californica* (naiads)	BSA	–	0.038 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Sodium azide	*Procambarus clarki* *Lepomis macrochirus*	BSA	–	1.0 (K1)* 1.0 (K1)** 1.5 (T1A)* 1.8 (T1A)** *Technical formulation **Granular	a	In general, when mud was added to the tank the toxicity of the chemical decreased.	Hughes (1966)
Sodium azide	*Pteronarcys californica* (naiads)	BSA	–	0.0092 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Sodium benzenesulfonate	*Daphnia magna*	BSA	–	(O)	a c	Assay water was not characterized chemically or otherwise described. The pH at 100 percent toxicity was 7.1. The 100-hr threshold was 2840%, with 0 percent toxicity at 1895% and 100 percent toxicity at 8000%.	Freeman (1953)
Sodium benzoate	*Daphnia magna*	BSA	–	<650 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water. This salt may be toxic only when the concentration is great enough to exert an unfavorable osmotic effect.	Anderson (1946)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Sodium benzoate	Sewage organisms	BOD	–	(NTE)	–	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Sodium o-benzoyl sulfimide (soluble saccharin)	Sewage organisms	BOD	–	>1000 (TC_{50})	a	Comment same as above.	Hermann (1959)
Sodium bicarbonate	*Polycelis nigra*	BSA	–	0.085 M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 6.4. Solutions were renewed every 12 hours.	Jones (1941)
Sodium bicarbonate	*Daphnia magna*	BSA	–	4200 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Sodium bicarbonate	*Daphnia magna*	BSA	–	2350 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water. This report toxic value may be due to an unfavorable osmotic effect.	Anderson (1946)
Sodium bicarbonate	*Lepomis macrochirus*	BCFA	–	8,250 (T4A) small 8,600 (T4A) medium 9,000 (T4A) large	a c e f	Test water was composed of distilled water through CP grade chemicals and was aerated throughout the 96-hour exposure period. At pH 7, the ratio of bicarbonate to carbonate was 2270:1.	Cairns and Scheier (1955)
Sodium bicarbonate	*Gambusia affinis*	BSA	–	7,550 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Sodium bicarbonate	*Lepomis macrochirus*	BSA	–	9000 (T4A)	a c d e i	A "control" was prepared by adding required chemicals to distilled water, and this was constantly aerated. Data reported are for larger fish, app. 14.24 cm in length. Data for smaller fish are also in the report.	Cairns and Scheier (1959)
Sodium bicarbonate	*Culex* sp (larvae)	BSA	–	2,000 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)

Sodium bicarbonate	*Nitzschia linearis* *Lepomis macrochirus*	BSA	–	650 (T5A) 8,600 (T4A)	a c e	The purpose of this experiment was to determine whether there was a constant relationship between the responses of these organisms. From the data presented, there was no apparent relationship of this type. Therefore the authors advise that bioassays on at least 3 components of the food web be made in any situation.	Patrick, et al (1968)
Sodium bisulfate	*Daphnia magna*	BSA	–	190 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water. Toxic effect may be a result of lowering the pH below 6.0.	Anderson (1946)
Sodium bisulfate	*Daphnia magna*	BSA	–	153.4 (O)	a c	The primary aim of this study was to determine the effects of lowered dissolved oxygen concentration upon an aquatic invertebrate when exposed to solutions of inorganic salts known to be present in various industrial effluents. Analysis of data conclusively shows the *D. magna* tested under lowered oxygen tension exhibited lower threshold values for the chemicals studied than when tested at atmospheric dissolved oxygen.	Fairchild (1955)
Sodium bisulfate	*Culex* sp (larvae)	BSA	–	300 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Sodium bisulfite	*Daphnia magna*	BSA	–	<145 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water.	Anderson (1946)
Sodium bisulfite	*Daphnia magna*	BSA	–	102 (O)	a c	Standard reference water used. Toxicity threshold is defined as that concentration which immobilizes 50 percent in a 100-hr exposure period.	Freeman and Fowler (1953)
Sodium bisulfite- Sodium sulfate	*Daphnia magna*	BSA	–	82 (O) 3642 (O)	a c	Comment same as above.	Freeman and Fowler (1953)
Sodium bisulfite- Sodium carbonate	*Daphnia magna*	BSA	–	850 (O) 436 (O)	a c	Comment same as above.	Freeman and Fowler (1953)
Sodium bisulfite- Sodium carbonate- Sodium chromate	*Daphnia magna*	BSA	–	87 (O) 440 (O) 0.35 (O)	a c	Comment same as above.	Freeman and Fowler (1953)
Sodium bisulfite- Sodium carbonate- Sodium silicate	*Daphnia magna*	BSA	–	38 (O) 194 (O) 92 (O)	a c	Comment same as above.	Freeman and Fowler (1953)
Sodium bisulfite- Sodium silicate	*Daphnia magna*	BSA	–	177 (O) 427 (O)	a c	Comment same as above.	Freeman and Fowler (1953)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Sodium bisulfite- Sodium chromate	*Daphnia magna*	BSA	–	70 (O) 0.286 (O)	a c	Standard reference water used. Toxicity threshold is defined as that concentration which immobilizes 50 percent in a 100-hr exposure period.	Freeman and Fowler (1953)
Sodium bisulfite- Sodium silicate- Sodium sulfate	*Daphnia magna*	BSA	–	52 (O) 126 (O) 2308 (O)	a c	Comment same as above.	Freeman (1953)
Sodium bisulfite- Sodium chromate- Sodium silicate	*Daphnia magna*	BSA	–	144 (O) 0.861 (O) 506 (O)	a c	Comment same as above.	Freeman (1953)
Sodium bisulfite- Sodium carbonate- Sodium sulfate	*Daphnia magna*	BSA	–	58 (O) 295 (O) 2562 (O)	a c	Comment same as above.	Freeman (1953)
Sodium bisulfite- Sodium chromate- Sodium sulfate	*Daphnia magna*	BSA	–	75 (O) 0.306 (O) 3312 (O)	a c	Comment same as above.	Freeman (1953)
Sodium bisulfite	*Daphnia magna*	BSA	–	61.4 (O)	a c	The primary aim of this study was to determine the effects of lowered dissolved oxygen concentration upon an aquatic invertebrate when exposed to solutions of inorganic salts known to be present in various industrial effluents. Analysis of data conclusively shows the *D. magna* tested under lowered oxygen tension exhibited lower threshold values for the chemicals studied than when tested at atmospheric dissolved oxygen.	Fairchild (1955)
Sodium bisulfite	*Gambusia affinis*	BSA	–	240 (T2A)	a c d e g	The effect of turbidity on the toxicity on the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Sodium bisulfite	*Daphnia magna* (young) *Daphnia magna* (adult) *Dugesia* sp	BSA	–	116 (T2A) 102 (T4A) 179 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)

	Lymnaea sp (eggs) *Mollienesia latopinna*			241 (T1A)			
Sodium bisulfite plus sodium silicate	*Daphnia magna*	BSA	–	950-14,210 (T1A) 785-11,723 (T2A) 15-22 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water. The two TL_m values are the respective concentration of each of the chemicals listed.	Dowden and Bennett (1965)
Sodium bisulfite plus sodium carbonate	*Daphnia magna*	BSA	–	436 (T4A) 85 (T4A)	a c	Comment same as above.	Dowden and Bennett (1965)
Sodium bisulfite plus sodium chromate	*Daphnia magna*	BSA	–	68 (T4A) 0.278 (T4A)	a c	Comment same as above.	Dowden and Bennett (1965)
Sodium bisulfite plus sodium sulfate	*Daphnia magna*	BSA	–	82 (T4A) 3,654 (T4A)	a c	Comment same as above.	Dowden and Bennett (1965)
Sodium bisulfite plus sodium carbonate and sodium chromate	*Daphnia magna*	BSA	–	86 (T4A) 441 (T4A) 0.354 (T4A)	a c	Comment same as above.	Dowden and Bennett (1965)
Sodium bisulfite plus sodium chromate and sodium sulfate	*Daphnia magna*	BSA	–	78 (T4A) 0.32 (T4A) 3,443 (T4A)	a c	Comment same as above.	Dowden and Bennett (1965)
Sodium bisulfite plus sodium carbonate and sodium silicate	*Daphnia magna*	BSA	–	39 (T4A) 198 (T4A) 93 (T4A)	a c	Comment same as above.	Dowden and Bennett (1965)
Sodium bisulfite plus sodium chromate and sodium silicate	*Daphnia magna*	BSA	–	224 (T4A) 0.086 (T4A) 506 (T4A)	a c	Comment same as above.	Dowden and Bennett (1965)
Sodium bisulfite plus sodium carbonate and sodium sulfate	*Daphnia magna*	BSA	–	57 (T4A) 296 (T4A) 2,869 (T4A)	a c	Comment same as above.	Dowden and Bennett (1965)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Sodium bisulfite plus sodium silicate and sodium sulfate	*Daphnia magna*	BSA	–	52 (T4A) 126 (T4A) 2,326 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water. Each of the three TL_m values represents the concentration of each of the chemicals, respectively.	Dowden and Bennett (1965)
Sodium borate	*Polycelis nigra*	BSA	–	0.026 M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 6.8. Solutions were renewed every 12 hours.	Jones (1941)
Sodium borate	*Daphnia magna*	BSA	–	<240 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water. Threshold value may be only half of that reported.	Anderson (1946)
Sodium borate (ore)	*Salmo gairdnerii*	BSA	–	2800 (T1A) 1800 (T2A)	a e	Most of the weed-killer formulations in this study consisted of more than one substance, i.e., oils, emulsifiers, stabilizers, and other adjuvants.	Alabaster (1956)
Sodium borate	*Gambusia affinis*	BSA	–	8,200 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Sodium bromate	*Polycelis nigra*	BSA	–	0.020 M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 6.6. Solutions were renewed every 12 hours.	Jones (1941)
Sodium bromate	*Daphnia magna*	BSA	–	210 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water.	Anderson (1946)
Sodium bromide	*Polycelis nigra*	BSA	–	0.14 M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 6.6. Solutions were renewed every 12 hours.	Jones (1941)
Sodium bromide	*Daphnia magna*	BSA	–	8200 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water. This salt may show toxicity when the concentration is high enough to exert unfavorable osmotic effect.	Anderson (1946)
Sodium p-bromo-benzene-sulfonate	*Daphnia magna*	BSA	–	843 (K)	a c	Assay water was not characterized chemically or otherwise described. The pH at 100 percent toxicity was 6.9.	Freeman (1953)

Sodium p-bromo-benzene-sulfonate	*Daphnia magna* *Lepomis macrochirus* *Lymnaea* sp (eggs)	BSA	–	523 (T4A) 1,560 (T1A) 2,590 (T1-4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Sodium n-butyl-sulfonate	*Daphnia magna*	BSA	–	7,827 (K)	a c	Assay water was not characterized chemically or otherwise described. The pH at 100 percent toxicity was 7.1.	Freeman (1953)
Sodium butyl sulfonate	*Daphnia magna*	BSA	–	8,000 (T1A) 5,400 (T3A) 2,700 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Sodium butyrate	*Lepomis macrochirus*	BSA	–	5,000 (T1A)	a c	Comment same as above.	Dowden and Bennett (1965)
Sodium carbonate	*Daphnia magna*	BSA	–	424 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Sodium carbonate	*Micropterus salmoides* *Lepomis macrochirus* Goldfish	BSA	–	500 (O) 500 (O) 500 (O)	a c f p i	The disposal of cannery wastes frequently involves the use of chemicals for treatment purposes. Ferrous sulphate, alum, and lime are used in chemical coagulation; sodium carbonate for acidity control in biological filters; and sodium nitrate in lagoons for odor control. Lye (sodium hydroxide) peeling of certain fruits and vegetables is not uncommon. These chemicals, in whole or part, are discharged in most cases to a stream. The concentrations listed permitted largemouth bass to survive 7 to 9 hours, bluegills to survive 4.5 to 11 hours, and goldfish to survive indefinitely.	Sanborn (1945)
Sodium carbonate	*Daphnia magna*	BSA	–	<424 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water. Toxic effect may be due in part to the rise in pH to 9.2.	Anderson (1946)
Sodium carbonate	*Oncorhyncus tshawytscha* *Oncorhyncus kisutch* *Salmo clarkii*	BSA	–	68 (K5) 70 (K5) 80 (K5)	a d e	This chemical is one of a number that may be found in Kraft mill waste effluents. Data are expressed as minimum lethal concentration for 5 days.	Haydu, et al (1952)
Sodium carbonate	*Daphnia magna*	BSA	–	524 (O)	a c	Standard reference water used. Toxicity threshold is defined as that concentration which immobilizes 50 percent in a 100-hr exposure period.	Freeman and Fowler (1953)
Sodium carbonate	*Lepomis macrochirus*	BCFA	–	300 (T4A)	a c e f	Test water was composed of distilled water with CP grade chemicals and was aerated throughout the 96-hr exposure period. Toxicity was essentially determined by pH. At pH 10 the carbonate to bicarbonate ratio was 1:2.27.	Cairns and Scheier (1955)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Sodium carbonate	*Daphnia magna*	BSA	–	552.4 (O)	a c	The primary aim of this study was to determine the effects of lowered dissolved oxygen concentration upon an aquatic invertebrate when exposed to solutions of inorganic salts known to be present in various industrial effluents. Analysis of data conclusively shows the *D. magna* tested under lowered oxygen tension exhibited lower threshold values for the chemicals studied than when tested at atmospheric dissolved oxygen.	Fairchild (1955)
Sodium carbonate	*Gambusia affinis*	BSA	–	840 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Sodium carbonate	*Lepomis macrochirus*	BSA	–	300 (T4A)	a c e d i	A "control" was prepared by adding required chemicals to distilled water, and this was constantly aerated. Data reported are for larger fish, app. 14.24 cm in length. Data for smaller fish are also in the report.	Cairns and Scheier (1959)
Sodium carbonate	Amphipoda	BSA	–	360 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
	Culex sp (larvae)			1,820 (T1A)			
	Daphnia magna			347 (T1A)			
	Dugesia sp			607 (T1A)			
	Lepomis macrochirus			384 (T1A)			
	Lymnaea sp. (eggs)			385 (T1A)			
	Mollienesia latopinna			403 (T1A) 405 (T2A)			
Sodium carbonate	*Nitzschia linearis*	BSA	–	242 (T5A)	a c e	The purpose of this experiment was to determine whether there was a constant relationship between the responses of these organisms. From the data presented, there was no apparent relationship of this type. Therefore the authors advise that bioassays on at least 3 components of the food web be made in any situation.	Patrick, et al (1968)
	Lepomis macrochirus			320 (T4A)			
Sodium carbonate- Sodium chromate	*Daphnia magna*	BSA	–	408 (O) 0.33 (O)	a c	Standard reference water used. Toxicity threshold is defined as that concentration which immobilizes 50 percent in a 100-hr exposure period.	Freeman and Fowler (1953)
Sodium carbonate plus sodium chromate	*Daphnia magna*	BSA	–	420 (T4A) 0.34 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water. Each value represents the concentration of each respective chemical.	Dowden and Bennett (1965)
Sodium carbonate- Sodium silicate	*Daphnia magna*	BSA	–	180 (O) 85 (O)	a c	Standard reference water used. Toxicity threshold is defined as that concentration which immobilizes 50 percent in a 100-hr exposure period.	Freeman and Fowler (1953)

Sodium carbonate plus sodium silicate	*Daphnia magna*	BSA	–	265 (T1A) 130 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water. Each TL_m value is equal to the concentration of each respective chemical.	Dowden and Bennett (1965)
Sodium carbonate-Sodium sulfate	*Daphnia magna*	BSA	–	221 (O) 1,918 (O)	a c	Standard reference water used. Toxicity threshold is defined as that concentration which immobilizes 50 percent in a 100-hr exposure period.	Freeman and Fowler (1953)
Sodium carbonate plus sodium sulfate	*Daphnia magna*	BSA	–	198 (T1A) 666 (T1A) 172 (T2A) 577 (T2A) 66 (T3A) 222 (T3A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water. Each TL_m value is equal to the concentration of each respective chemical.	Dowden and Bennett (1965)
Sodium carbonate-Sodium chromate-Sodium silicate	*Daphnia magna*	BSA	–	182 (O) 0.146 (O) 86 (O)	a c	Standard reference water used. Toxicity threshold is defined as that concentration which immobilizes 50 percent in a 100-hr exposure period.	Freeman and Fowler (1953)
Sodium carbonate plus sodium chromate and sodium silicate	*Daphnia magna*	BSA	–	187 (T4A) 0.15 (T4A) 88 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water. Each TL_m value represents the concentration of each respective chemical.	Dowden and Bennett (1965)
Sodium carbonate-Sodium chromate-Sodium sulfate	*Daphnia magna*	BSA	–	240 (O) 0.192 (O) 2079 (O)	a c	Standard reference water used. Toxicity threshold is defined as that concentration which immobilizes 50 percent in a 100-hr exposure period.	Freeman and Fowler (1953)
Sodium carbonate plus sodium chromate and sodium sulfate	*Daphnia magna*	BSA	–	240 (T4A) 0.19 (T4A) 2,078 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water. Each TL_m value represents the concentration of each respective chemical.	Dowden and Bennett (1965)
Sodium carbonate-Sodium silicate-Sodium sulfate	*Daphnia magna*	BSA	–	155 (O) 73 (O) 1343 (O)	a c	Standard reference water used. Toxicity threshold is defined as that concentration which immobilizes 50 percent in a 100-hr exposure period.	Freeman and Fowler (1953)
Sodium carbonate plus sodium silicate and sodium sulfate	*Daphnia magna*	BSA	–	161 (T4A) 76 (T4A) 1,396 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water. Each TL_m value is equal to the concentration of each respective chemical.	Dowden and Bennett (1965)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Sodium carboxyethyl rosin amine	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – PT (14) Ma – PT (14) So – NT Cv – NT Gp – T (3) Np – NT	Palmer and Maloney (1955)
Sodium chlorate	*Polycelis nigra*	BSA	–	0.15 M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 6.4. Solutions were renewed every 12 hours.	Jones (1941)
Sodium chlorate	*Daphnia magna*	BSA	–	4240 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water.	Anderson (1946)
Sodium chlorate	*Salmo gairdnerii*	BSA	–	4200 (T1A) 2750 (T2A)	a e	Most of the weed-killer formulations in this study consisted of more than one substance, i.e., oils, emulsifiers, stabilizers, and other adjuvants.	Alabaster (1956)
Sodium chloride	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, possible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compares this work with earlier work, and lists an extensive bibliography. In 0.27N solution, the fish survived 178 minutes.	Powers (1918)
Sodium chloride	*Polycelis nigra*	BSA	–	0.19 M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 7.0. Solutions were renewed every 12 hours.	Jones (1941)
Sodium chloride	*Daphnia magna*	BSA	–	6143 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)

Sodium chloride	Brook trout	BSA	–	(O)	–	Fish were fed NaCl in gelatin capsules in amounts of 5.0 to 25.0 mg. Fish averaged 5.6 grams in weight. Physical effects of the salt were exhibited rather than true toxicity. Fish were also immersed in NaCl solution. Immersion in a 2.5% solution produced no increase in blood salt concentration. A 30-minute bath in 3.0% salt or a 10-minute bath in 5.0% salt caused a rise in blood salinity that quickly returned to normal when the fish were placed in fresh water. A 60-minute bath in 3.0% salt resulted in a very high blood salt level that required 48 hours to return to normal. A 15-minute bath in a 5.0% solution resulted in the loss of the majority of the fish.	Phillips (1944)
Sodium chloride	*Daphnia magna*	BSA	–	<4200 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water.	Anderson (1946)
Sodium chloride	*Daphnia magna*	BSA	–	3,680 (S)	a	Lake Erie water was used as diluent. Toxicity given as threshold concentration producing immobilization for exposure periods of 64 hours.	Anderson (1948)
Sodium chloride	*Lepomis macrochirus*	BSA	–	12,946 (T4A)	a d e f	This paper reports the LD_{50} in 96 hours for 8 common inorganic salts. A synthetic dilution water of controlled hardness was prepared for use in the experiments. Among other variables, specific conductivity, as mhos at 20 C, was measured. If this salt is toxic to fish, this experiment did not demonstrate it. A saturated solution of 2,980 ppm produced no significant mortalities.	Trama (1954)
Sodium chloride	*Daphnia magna*	BSA	–	5,093 (O)	a c	The primary aim of this study was to determine the effects of lowered dissolved oxygen concentration upon an aquatic invertebrate when exposed to solutions of inorganic salts known to be present in various industrial effluents. Analysis of data conclusively shows the *D. magna* tested under lowered oxygen tension exhibited lower threshold values for the chemicals studied than when tested at atmospheric dissolved oxygen.	Fairchild (1955)
Sodium chloride	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – NT Ma – NT So – NT Cv – NT Gp – NT Np – NT	Palmer and Maloney (1955)
Sodium chloride	*Biomorpholaria a. alexandrina* *Bulinus truncatus* *Lymnaea caillaudi*	BSA	–	4100 (K1A) 2600 (K1A) 2600 (K1A)	a	The degree of tolerance for vector snails of biharziasis chemicals is somewhat dependent upon temperature. The temperature at which (K1A) occurred was 26 C.	Gohar and El-Gindy (1961)

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Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Sodium chloride	*Gambusia affinis*	BSA	–	18,100 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Sodium chloride	*Limnodrilus hoffmeisteri* *Erpobdella punctata* *Helisoma campanulata* *Gyraulus circumstriatus* *Physa heterostropha* *Sphaerium* cf. *tenue* *Asellus communis* *Argia* sp	BSA	–	6200 (T4A) 7500 (T4A) 6150 (T4A) 3200 (T4A) 3500 (T4A) 5100 (T4A) 6200 (T4A) 1100 (T4A) 1150 (T4A) 8250 (T4A) 24,000 (T4A)	a c d i	Most of the data developed was with hard water, but experiments with soft water were also conducted. Additional TL_m data are presented.	Wurtz and Bridges (1961)
Sodium chloride	*Hydropsyche* *Stenonema*	BSA	–	9,000 (T2A) 2,500 (T2A)	a	Soft water used as diluent water.	Roback (1965)
Sodium chloride	*Cyprinidae* *Asellus* sp *Hydropsyche* sp *Dressenia* sp *Calliriche* sp *Helosciadium* sp *Nodiflorum* sp *Oenanthe fluviatilis* *Lemna trisulca*	BSA	–	10,000 (L10A) 10,000 (L7 and K4FA) 10,000 (L6 and K17A) 10,000 (L5A) 10,000 (K13A) (O)	a	*L. trisulca* was not affected at 10,000 ppm.	Vivier and Nisbet (1965)
Sodium chloride	*Nais* spp	BSA	–	1.0% (T 36 min)	a f	All tests were conducted in hard water. Time given is median survival time of the worms.	Learner and Edwards (1963)
Sodium chloride	*Potamogeton pectinatus*	BSA	–	(O)	–	Increasing NaCl solutions produced a proportional adverse effect on vegetative growth and seed production, but a concentration of 3000 ppm stimulated the production and growth of tubers. 9000 ppm completely inhibited the growth of one-week-old plants. 15,000 ppm reduced growth completely and was fatal to many plants.	Teeter (1965)

Sodium chloride	*Carassius carassius*	BSA	–	13,750 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
	Culex sp (larvae)			10,500 (T1A)			
	Daphnia magna			6,447 (T1A)			
	Lepomis macrochirus			14,125 (T1A)			
	Lymnaea sp (eggs)			3,412 (T1A)			
	Mollienesia latopinna			18,735 (T1A)			
Sodium chloride	*Nitzschia linearis*	BSA	–	2,430 (T5A)	a c e	The purpose of this experiment was to determine whether there was a constant relationship between the responses of these organisms. From the data presented, there was no apparent relationship of this type. Therefore the authors advise that bioassays on at least 3 components of the food web be made in any situation.	Patrick, et al (1968)
	Lepomis macrochirus			12,940 (T4A)			
Sodium p-chlorobenzene sulfonate	*Daphnia magna*	BSA	–	3,007 (K)	a c	Assay water was not characterized chemically or otherwise described. The pH at 100 percent toxicity was 7.1.	Freeman (1953)
Sodium p-chlorobenzene sulfonate	*Daphnia magna*	BSA	–	2,394 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1956)
	Lepomis macrochirus			3,219 (T1A)			
	Lymnaea sp (eggs)			8,600 (T1A)			
Sodium 2-chlorotoluene-4-sulfonate	*Lepomis macrochirus*	BSA	–	1,374 (T1A)	a c	Comment same as above.	Dowden and Bennett (1965)
Sodium 2-chlorotoluene-5-sulfonate	*Daphnia magna* (young)	BSA	–	0.8 (T1A)	a c	Comment same as above.	Dowden and Bennett (1965)
	Daphnia magna (adult)			3.3 (T1A)			
	Lymnaea sp (eggs)			30. (T1A)			
	Mollienesia latopinna			115.2 (T1A)			
Sodium chromate	*Polycelis nigra*	BSA	–	0.0028M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 7.2. Solutions were renewed every 12 hours.	Jones (1941)
Sodium chromate	Sewage organisms	BOD	–	1.0 (O)	j	"Toxicity" is expressed as 10 percent reduction in oxygen utilization.	Ingols (1955)
Sodium chromate	*Daphnia magna*	BSA	–	<0.32 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water.	Anderson (1946)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Sodium chromate	*Daphnia magna*	BSA	–	0.42 (O)	a c	Standard reference water used. Toxicity threshold is defined as that concentration which immobilizes 50 percent in a 100-hr exposure period.	Freeman and Fowler (1953)
Sodium chromate	Sewage organisms	BOD	–	(O)	–	A concentration of 1.0 ppm produced an oxygen depletion in percent of the control of 90%. It required 10.0 ppm to produce 38% oxygen depletion. There is an apparent relationship between toxicity of chromium and the organic matter concentration in that higher amounts of organic matter complex with the chromium thus reducing its apparent toxicity.	Ingols (1954)
Sodium chromate	*Daphnia magna*	BSA	–	0.51 (O)	a c	The primary aim of this study was to determine the effects of lowered dissolved oxygen concentration upon an aquatic invertebrate when exposed to solutions of inorganic salts known to be present in various industrial effluents. Analysis of data conclusively shows the *D. magna* tested under lowered oxygen tension exhibited lower threshold values for the chemicals studied than when tested at atmospheric dissolved oxygen.	Fairchild (1955)
Sodium chromate	*Gambusia affinis*	BSA	–	500 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Sodium chromate	*Escherichia coli* *Saccharomyces ellipsoides*	L	–	(O)	–	This study suggests that the chromates have an effect on microbial genetic expression. Toxicity appeared to be in the range of 100 to 500 mg/l.	Ingols and Fetner (1961)
Sodium chromate	*Nereis* sp *Carcinus maenas* *Leander squilla*	BSA	–	0.5 (SB 21) 1.0 (SB 21) 60.0 (T12A) 50.0 (SB 12) 5.0 (SB 35)	a	The threshold toxicity for shore crabs was in the range of 40 to 60 ppm for a 12-day period of exposure. The threshold toxicity for prawns was a little less than 10 ppm in adults and 5 ppm in young.	Raymont and Shields (1964)
Sodium chromate- Sodium silicate- Sodium sulfate	*Daphnia magna*	BSA	–	0.201 (O) 119 (O) 2180 (O)	a c	Standard reference water used. Toxicity threshold is defined as that concentration which immobilizes 50 percent in a 100-hr exposure period.	Freeman and Fowler (1953)
Sodium chromate- Sodium sulfate	*Daphnia magna*	BSA	–	0.276 (O) 2984 (O)	a c	Comment same as above.	Freeman and Fowler (1953)
Sodium chromate- Sodium silicate	*Daphnia magna*	BSA	–	0.159 (O) 93 (O)	a c	Comment same as above.	Freeman and Fowler (1953)

Sodium chromate plus sodium silicate	*Daphnia magna*	BSA	–	0.21 (T4A) 130 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water. Each TL_m value is equal to the concentration of each respective chemical.	Dowden and Bennett (1965)
Sodium chromate plus sodium sulfate	*Daphnia magna*	BSA	–	0.28 (T4A) 3,044 (T4A)	a c	Comment same as above.	Dowden and Bennett (1965)
Sodium chromate plus sodium silicate and sodium sulfate	*Daphnia magna*	BSA	–	0.28 (T4A) 122 (T4A) 2,255 (T4A)	a c	Comment same as above.	Dowden and Bennett (1965)
Sodium citrate	*Polycelis nigra*	BSA	–	0.015M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 6.6. Solutions were renewed every 12 hours.	Jones (1941)
Sodium citrate	*Daphnia magna*	BSA	–	825 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water.	Anderson (1946)
Sodium cyanide	*Polycelis nigra*	BSA	–	0.0006M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 4.8. Solutions were renewed every 12 hours.	Jones (1941)
Sodium cyanide	*Daphnia magna*	BSA	–	<3.4 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water.	Anderson (1946)
Sodium cyanide	*Pimephales promelas*	BSA	–	0.23 (T4A)	a c	Synthetic soft water was used. Toxicity data given as number of test fish surviving after exposure at 24, 48, and 96 hr. TL_m values were estimated by straight-line graphical interpolation and given in ppm CN^-.	Doudoroff, et al (1956)
Sodium cyanide	Sewage organisms	BOD	–	3.6 (O)	–	Various metal salts were studied in relation to how they affected the BOD of both raw and treated sewage as well as how they affected the processing of sewage in the treatment plant. BOD was used as the parameter to measure the effect of the chemical. The chemical concentration cited is the ppm required to reduce the BOD values by 50%. This chemical was tested in an unbuffered system.	Sheets (1957)
Sodium cyanide	*Lepomis cyanellus*	FL	Carbondale, Ill.	1.0 (K1)	a	Green sunfish placed in cages in ponds 1 and 2 days after application of the chemical suffered 100 percent mortality at 1.0 ppm. Toxicity seemed to be less in waters exhibiting high pH or low temperature.	Bridges (1958)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Sodium cyanide	*Lepisosteus osseus* *Carassius auratus* *Cyprinus carpio* *Ictalurus natalis* *Micropterus salmoides* *Lepomis cyanellus*	BSA	–	1.0 (K <1)	a c e	After application of 1 ppm of the chemical to small farm ponds, fish began to surface within 5 to 30 minutes. At concentrations of 1 ppm and at a variety of temperature and pH conditions, effective kills of a number of different species of warm-water fishes were produced. Concentrations of 1 ppm produced complete kill of all species of fish within 8 hr.	Bridges (1958)
Sodium cyanide	*Pimephales promelas* *Lepomis macrochirus*	BSA	–	(H) 0.35 (T4A) (S) 0.23 (T4A) (H) 0.15 (T4A)	c d e f	(H) Value in hardwater. (S) Value in softwater.	Henderson, et al (1959)
Sodium cyanide	*Gasterosteus aculeatus* *Anguilla anguilla* *Phoxinus phoxinus* *Salmo trutta* *Carassius auratus*	BSA	–	0.49 (K 8 hr) 0.49 (K 12 hr) 0.49 (K 6 hr) 0.49 (K 2 hr) 4.9 (K 12 hr)	a c e	This rather long paper deals more with behavior (avoidance reaction time, etc.) than other aspects of toxicity. However, interpolation from several curves resulted in the concentrations quoted. Avoidance occurred at concentrations as low as 10^{-6} N.	Costa (1965)
Sodium cyanide	*Gammarus pulex*	BCFA	–	(O)	a c e	Temperature and pH were important factors determining the behavior and reaction time of *Gammarus* during exposure to solutions of this chemical. Most of the data were describing behavioral responses. However, in a solution of 0.00005N, the fish survived 1-1/2 hours. *Gammarus* were somewhat more resistant to sodium cyanide than fish.	Costa (1965)
Sodium cyanide	*Rana temporaria*	BCFA	–	(O)	a e	This report deals more with behavioral aspects than strict toxicity. The response limit for frog tadpoles is about 0.49 ppm. Increased temperature, a higher pH, and the amount of dissolved oxygen were critical. The response limit for tadpoles was 0.00001N. The tadpoles were less sensitive than fish but more sensitive than *Gammarus*.	Costa (1965)
Sodium cyanide	Green sunfish	BSA and FL	Okla.	(O)	–	Sodium cyanide was found to be moderately effective as a repellent at 5 mg/l and to produce an avoidance response at 1.0 mg/l. No response was noted at or below 0.5 mg/l.	Summerfelt and Lewis (1967)
Sodium 2,5-dichlorobenzenesulfonate	*Daphnia magna*	BSA	–	3,890 (K)	a c	Assay water was not characterized chemically or otherwise described. The pH at 100 percent toxicity was 7.1.	Freeman (1953)

Sodium 2,5-dichlorobenzene sulfonate	*Daphnia magna* *Lepomis macrochirus* *Lymnaea* sp (eggs)	BSA	–	1,468 (T4A) 3,750 (T4A) 4,513 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Sodium dichromate	*Gambusia affinis*	BSA	–	420 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Sodium dichromate	*Daphnia magna*	BSA	–	22 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Sodium dinitrophenate	*Phoxinus phoxinus*	BSA	–	250 ppm (17.7 min) 100 ppm (61.0 min) 50 ppm (209.0 min)	a c e f	Tap or distilled water used as diluent. Toxicity defined as the avg time when the fish lost equilibrium when exposed to the test chemical (ppm dinitrophenate).	Grindley (1946)
Sodium ferrocyanide	*Polycelis nigra*	BSA	–	0.0008M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 6.4. Solutions were renewed every 12 hours.	Jones (1941)
Sodium ferrocyanide	*Daphnia magna*	BSA	–	<600 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water.	Anderson (1946)
Sodium fluoride	*Polycelis nigra*	BSA	–	0.0011M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 7.2. Solutions were renewed every 12 hours.	Jones (1941)
Sodium fluoride	*Daphnia magna*	BSA	–	504 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water.	Anderson (1946)
Sodium fluoride	*Gambusia affinis*	BSA	–	925 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Sodium fluoride	Rainbow trout	BSA	–	5.9-7.5 (T2A)* 2.6-6.0 (T2A)** *45 F *55 F	a	This study postulates that temperature affects the toxicity of fluoride concentration because of its effect on the metabolic rate of the fish. TL_m values are given as LC_{50}.	Anonymous (1966)
Sodium fluoride	*Homarus americanus*	BSA	–	0.9-4.5 (SB10)	a c e	Fluoride was not toxic even at levels five times those generally used in municipal water supplies. The lobsters employed weighed 500 grams.	Stewart and Cormick (1964)
Sodium formate	*Daphnia magna*	BSA	–	<5200 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water. Toxic effect may be a result of unfavorable osmotic effect.	Anderson (1946)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Sodium formate	*Lepomis macrochirus*	BSA	–	5,000 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Sodium hydrosulfide	*Gambusia affinis*	BSA	–	206 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Sodium hydrosulfide	*Semotilus atromaculatus*	BSA	–	4 to 10 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Copeland and Woods (1959)
Sodium hydroxide	*Polycelis nigra*	BSA	–	0.000004M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 7.8. Solutions were renewed every 12 hours.	Jones (1941)
Sodium hydroxide	*Daphnia magna*	BSA	–	240 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Sodium hydroxide	*Micropterus salmoides* (large mouth bass) *Lepomis macrochirus* Goldfish	BSA	–	50 (O) 50 (O) 50 (O)	a c f p i	The disposal of cannery wastes frequently involves the use of chemicals for treatment purposes. Ferrous sulphate, alum, and lime are used in chemical coagulation; sodium carbonate for acidity control in biological filters; and sodium nitrate in lagoons for odor control. Lye (sodium hydroxide) peeling of certain fruits and vegetables is not uncommon. These chemicals, in whole or part, are discharged in most cases to a stream. The concentrations listed permitted fish to survive indefinitely.	Sanborn (1945)
Sodium hydroxide	*Daphnia magna*	BSA	–	156 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water. Toxic effect may be due to the rise in pH to 9.1-9.5.	Anderson (1946)
Sodium hydroxide	*Oncorhyncus tshawytscha* *Oncorhyncus kisutch* *Salmo clarkii clarkii*	BSA	–	48 (K5) 20 (K5) 35 (K5)	a d e	This chemical is one of a number that may be found in Kraft mill waste effluents. Data are expressed as minimum lethal concentration for 5 days.	Haydu, et al (1952)
Sodium hydroxide	*Semotilus Atromaculatus*	BSA	–	20 to 40 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)

Sodium hydroxide	*Lepomis macrochirus*	BCFA	–	(O)	a c e f	Test water was composed of distilled water with CP grade chemicals and was aerated throughout the 96-hour exposure period. At pH 9.8, all fish survived. At pH 9.9 to 10.1 after 4 days, only one-half survived. At pH 10.41 to 10.50, only 10 percent survived after 3 days.	Cairns and Scheier (1955)
Sodium hydroxide	*Lepomis gibbosus*	BSA	–	5 (K 3-5 min)	c	The author suggests placing pellets of sodium hydroxide in the nests of the sunfish when eggs or fry are present. This method for controlling sunfish was developed first in the laboratory in petri dishes and later conducted in the field.	Jackson (1956)
Sodium hydroxide	*Lepomis gibbosus*	FL	Durham, N. H.	5 (K 3-5 min)	a	The chemical must be applied after spawning begins and before the fry leave the nest. The author suggests placing pellets of sodium hydroxide in the nest of the sunfish when eggs or fry are present.	Jackson (1956)
Sodium hydroxide	*Gambusia affinis*	BSA	–	125 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Sodium hydroxide	*Lepomis macrochirus*	BSA	–	9.9 (pH, T4A)	a c d e i	A "control" was prepared by adding required chemicals to distilled water, and this was constantly aerated. Data reported are for larger fish, approximately 14.24 cm in length. Data for smaller fish are also in the report.	Cairns and Scheier (1959)
Sodium hydroxide	*Biomorpholaria a. alexandrina* *Bulinus truncatus* *Lymnaea caillaudi*	BSA	–	450 (K1A) 150 (K1A) 150 (K1A)	a	The degree of tolerance for vector snails of biharziasis to chemicals is somewhat dependent upon temperature. The temperature at which (K1A) occurred was 27 C.	Gohar and El-Gindy (1961)
Sodium iodate	*Polycelis nigra*	BSA	–	0.0013M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 8.0. Solutions were renewed every 12 hours.	Jones (1941)
Sodium iodide	*Polycelis nigra*	BSA	–	0.044M (L2)	c	Comment same as above.	Jones (1941)
Sodium iodide	*Daphnia magna*	BSA	–	3.3 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water.	Anderson (1946)
Sodium iodate	*Daphnia magna*	BSA	–	<158 (O)	–	Comment same as above except value may be only half of that reported.	Anderson (1946)
Sodium metaarsenite	Sewage organisms	BOD	–	(NTE)	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Sodium monohydrogen phosphate	*Daphnia magna*	BSA	–	1,154 (T1A) 1,089 (T2A) 426 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Sodium mono-hydrogen phosphate plus sodium pyrophosphate	*Daphnia magna* *Lymnaea* sp (eggs)	BSA	–	3,580 (T1A) 433 (T1A) 2,685 (T1A) 63 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water. Each TL_m value is equal to the concentration of each respective chemical.	Dowden and Bennett (1965)
Sodium napthalene B-sulfonate	*Daphnia magna*	BSA	–	308 (K)	a c	Assay water was not characterizied chemically or otherwise described. The pH at 100 percent toxicity was 7.1.	Freeman (1953)
Sodium nitrate	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, possible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compares this work with earlier work, and lists an extensive bibliography. In 0.220N solution, fish survived 171 minutes.	Powers (1918)
Sodium nitrate	*Gasterosteus aculeatus*	BSA	–	500 (K10)	–	Solutions were made up in tap water. 3.0 to 5.0 cm stickleback fish were used as experimental animals. This paper points out that there is a marked relationship between the toxicity of the metals and their solution pressures. Those with low solution pressures were the most toxic.	Jones (1939)
Sodium nitrate	*Polycelis nigra*	BSA	–	0.043M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 7.2. Solutions were renewed every 12 hours.	Jones (1941)
Sodium nitrate	*Daphnia magna*	BSA	–	8,500 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Sodium nitrate	*Micropterus salmoides* *Lepomis macrochirus* Goldfish	BSA	–	4,000 (O) 2,000 (O) 2,000 (O)	a c f p i	The disposal of cannery wastes frequently involves the use of chemicals for treatment purposes. Ferrous sulphate, alum, and lime are used in chemical coagulation; sodium carbonate for acidity control in biological filters; and sodium nitrate in lagoons for odor control. Lye (sodium hydroxide) peeling of certain fruits and vegetables is not uncommon. These chemicals, in whole or part, are discharged in most cases to a stream. The concentrations listed permitted large mouth bass to survive indefinitely, bluegills to survive 3 days to indefinitely, and goldfish to survive 4 days.	Sanborn (1945)
Sodium nitrate	*Daphnia magna*	BSA	–	5,000 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water. Toxic effect may be caused when the chemical concentration is high enough to exert unfavorable osmotic effect.	Anderson (1946)

Sodium nitrate	*Lepomis macrochirus*	BSA	–	12,000 (T4A)	a d e f	This paper reports the LD_{50} in 96 hours for 8 common inorganic salts. A synthetic dilution water of controlled hardness was prepared for use in the experiments. Among other variables, specific conductivity, as mhos at 20 C, was measured. If this salt is toxic to fish, this experiment did not demonstrate it.	Trama (1954)
Sodium nitrate	*Lepomis macrochirus*	BCFA	–	9,500 (T4A)	a c e f	Test water was composed of distilled water with CP grade chemicals and was aerated throughout the 96-hour exposure period.	Cairns and Scheier (1955)
Sodium nitrate	*Gambusia affinis*	BSA	–	10,000 (T2A)	a c d e g	The effect of turbidity on the toxicity on the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Sodium nitrate	*Lepomis macrochirus*	BSA	–	9,000 (T4A)	a c d e i	A "control" was prepared by adding required chemicals to distilled water, and this was constantly aerated. Data reported are for larger fish, approximately 14.24 cm in length. Data for smaller fish are also in the report.	Cairns and Scheier (1959)
Sodium nitrite	Sewage organisms	BOD	–	(NTE)	–	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Sodium nitrate	*Biomorpholaria a. alexandrina* *Bulinus truncatus*	BSA	–	6,000 (K1A) 3,100 (K1A)	a	The degree of tolerance for vector snails of biharziasis to chemicals is somewhat dependent upon temperature. The temperature at which (K1A) occurred was 28 C for *Bulinus* and 26 C for *Biomophalaria.*	Gohar and El-Gindy (1961)
Sodium nitrate	*Carassius carassius* *Daphnia magna* *Lepomis macrochirus* *Lymnaea* sp (eggs)	BSA	–	12,150 (T1A) 4,206 (T4A) 12,800 (T1A) 6,375 (T1A) 5,950 (T2A) 3,251 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Sodium nitrite	*Polycelis nigra*	BSA	–	0.0006M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 6.0. Solutions were renewed every 12 hours.	Jones (1941)
Sodium nitrite	*Daphnia magna*	BSA	–	<20 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in entrifuged Lake Erie water.	Anderson (1946)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Sodium nitrite	*Semotilus atromaculatus*	BSA	–	400 to 2000 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
Sodium nitrite	*Gambusia affinis*	BSA	–	7.5 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Sodium m-nitrobenzene sulfonate	*Daphnia magna* *Lepomis macrochirus*	BSA	–	2,235 (T4A) 1,350 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Sodium m-nitrobenzene sulfonate	*Daphnia magna*	BSA	–	5,618 (K)	a c	Assay water was not characterized chemically or otherwise described. The pH at 100 percent toxicity was 8.6.	Freeman (1953)
Sodium 4-nitrochloro-benzene-2-sulfonate	*Daphnia magna* *Lepomis macrochirus* *Lymnaea* sp (eggs)	BSA	–	1,474 (T4A) 6,375 (T4A) 3,532 (T1A) 3,208 (T2A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Sodium 4-nitrochloro-benzene-2-sulfonate	*Daphnia magna*	BSA	–	3,187 (K)	a c	Assay water was not characterized chemically or otherwise described. The pH at 100 percent toxicity was 6.9.	Freeman (1953)
Sodium nitroprusside	*Polycelis nigra*	BSA	–	0.0008M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 6.0. Solutions were renewed every 12 hours.	Jones (1941)
Sodium nitroprusside	*Daphnia magna*	BSA	–	<210 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water. Value may be half of that reported.	Anderson (1946)
Sodium 4-nitrotoluene-2-sulfonate	*Lepomis macrochirus*	BSA	–	1,440 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Sodium oxalate	*Polycelis nigra*	BSA	–	0.011m (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 7.2. Solutions were renewed every 12 hours.	Jones (1941)

Sodium oxalate	*Daphnia magna*	BSA	–	214 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water.	Anderson (1946)
Sodium oxalate	*Gambusia affinis*	BSA	–	1,350 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Sodium oxalate	Sewage organisms	BOD	–	(NTE)	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Sodium oxalate	*Lepomis macrochirus*	BSA	–	4,000 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Sodium pentachlorophenate	*Erisymba buccata (EB)* *Notropis umbratilis (NU)* *Pimephales notatus (PN)* *Campostoma anomalum* *Notropis whipplii (NW)* *Semotilus atromaculatus (SA)* *Fundulus notatus (FN)* *Lepomis humilis (LH)* Tadpole	BSA	–	(O)	a c e i	Survival time in minutes for each species at 5.0 ppm was: EB – 23 minutes NU – 16 minutes PN – 42 minutes CA – 13 minutes NW – 15 minutes SA – 30 minutes FN – 90 minutes LH – 25 minutes Tadpole – 75 minutes Crayfish, amphipods, cladocera, dragon fly nymphs, damsel fly nymphs and isopods all survived 5.0 ppm, but this concentration killed bloodworms.	Goodnight (1942)
Sodium pentachlorophenate (88 percent)	*Lymnaeid* snails	BSA	–	(O)	–	Each test container (500-ml beaker) was filled with ditch water. 100% mortality occurred in concentrations of 1:400,000 and greater.	Bette, et al (1951)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Sodium pentachlorophenate	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – T (3) Ma – T (3) So – PT (7) Cv – NT Gp – PT (7) Np – T (3)	Palmer and Maloney (1955)
Sodium pentachlorophenate	*Lebistes reticulatus*	BSA	–	2 (K 94%-1440 min) 4 (K 100%-300 min) 8 (K 100%-90 min) 15 (K 100%-40 min) 25 (K 100%-25 min)	–	Standard curves are developed for use in determining concentrations for molluscicidal use in field conditions.	Klock (1956)
Sodium pentachlorophenate	*Pimephales promelas*	BSA	–	0.32-0.35 (T1A)	a c d f	Temperature and pH were studied as variables. The lower the pH, the more toxic the chemical was to the fish. As temperature was increased the toxicity rose proportionately.	Crandall and Goodnight (1959)
Sodium pentachlorophenolate	Channel catfish (fingerlings)	BSA	–	0.46 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Sodium pentachlorophenate	*Lebistes reticulatus*	BSCH	–	0.5 (44.6% K 90)	a c d e	Sublethal effects found were retarded growth.	Crandall and Goodnight (1962)
Sodium pentachlorophenate	*Oncorhynchus kisutch*	BSA	–	3.0 (O)	a e	The value reported is obtained by a complex mathematical treatment and is for "median resistance times" of juvenile salmon with varying levels of salinity, temperature, and dissolved oxygen. At 3.0 mg/l pentachlorophenate, the maximum response (toxicity) was calculated to be 17.68% salt concentration, 4.86 c, and 7.66 mg/l of dissolved oxygen.	Alderdice (1963)
Sodium pentachlorophenate	Tubificid worms	BSA	–	0.31 (T1A)	a c	Knop's solution was used. TL_m levels for various pH's were determined. This compound was more toxic at the lower pH levels studied.	Whitley (1968)

Sodium pentachlorophenate plus sodium salts of other phenols	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – PT Ma – PT (14), NT (21) So – PT (14), NT (21) Cv – NT Gp – PT (7) Np – T (3)	Palmer and Maloney (1955)
Sodium perborate	*Daphnia magna*	BSA	–	<5.2 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water.	Anderson (1946)
Sodium p-phenol sulfonate	*Daphnia magna*	BSA	–	5,623 (K)	a c	Assay water was not characterized chemically or otherwise described. The pH at 100 percent toxicity was 6.7.	Freeman (1953)
Sodium p-phenol sulfonate	*Daphnia magna* *Lepomis macrochirus* *Lymnaea* sp (eggs)	BSA	–	1,471 (T4A) 19,616 (T4A) 8,828 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Sodium phosphate	*Polycelis nigra*	BSA	–	0.026M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 6.6. Solutions were renewed every 12 hours.	Jones (1941)
Sodium phosphate	*Gambusia affinis*	BSA	–	720 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Sodium phosphate	*Daphnia magna*	BSA	–	237 (T1A) 177 (T2A) 126 (T3A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Sodium picrate	*Phoxinus phoxinus*	BSA	–	2000 ppm (192 min) 1000 ppm (369 min) 200 ppm (1563 min)	a c e f	Tap or distilled water used as diluent. Toxicity defined as the average time when the fish lost equilibrium when exposed to the test chemical (ppm picrate).	Grindley (1946)
Sodium propionate	*Culex* sp (larvae) *Lepomis macrochirus*	BSA	–	2,320 (T2A) 5,000 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Sodium pyrophosphate	*Gambusia affinis*	BSA	–	1,380 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Sodium pyrophosphate	*Daphnia magna*	BSA	–	433 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Sodium salicylate	*Daphnia magna*	BSA	–	1,450 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water.	Anderson (1946)
Sodium silicate	*Daphnia magna*	BSA	–	2.47 (O)	a c	Standard reference water used. Toxicity threshold is defined as that concentration which immobilizes 50 percent in a 100-hr exposure period.	Freeman and Fowler (1953)
Sodium silicate	*Gambusia affinis*	BSA	–	2,400 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Sodium silicate	Amphipoda *Daphnia magna* *Lymnaea* sp (eggs)	BSA	–	895 (T1A) 263 (T2A) 160 (T4A) 247 (T4A) 630 (T1-4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Sodium silicate- Sodium sulfate	*Daphnia magna*	BSA	–	158 (O) 2,899 (O)	a c	Standard reference water used. Toxicity threshold is defined as that concentration which immobilizes 50 percent in a 100-hr exposure period.	Freeman and Fowler (1953)
Sodium stearate	*Pimephales promelas* (juveniles)	BSA	–	(S) 200 (T1-4A) (H) 1,800 (T1-4A)	a c d f	Syndets and soaps were of nearly equal toxicity in soft water (S) but syndets were approximately 40X more toxic than soap in hard water (H). Pure compound was less toxic than packaged soap products.	Henderson, et al (1959)
Sodium sulfate	*Polycelis nigra*	BSA	–	0.048M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 6.6. Solutions were renewed every 12 hours.	Jones (1941)
Sodium sulfate	*Daphnia magna*	BSA	–	7,105 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Sodium sulfate	*Daphnia magna*	BSA	–	5,960 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water. This salt may be innocuous until the concentration exerts an unfavorable osmotic effect.	Anderson (1946)

Sodium sulphate	*Oncorhyncus kisutch* *Salmo clarkii clarkii*	BSA	–	16,500 (K5A) 6,700 (K5A)	a d e	This chemical is one of a number that may be found in Kraft mill waste effluents. Data are expressed as minimum lethal concentration for 5 days.	Haydu, et al (1952)
Sodium sulfate	*Lepomis macrochirus*	BSA	–	13,500 (T4A)	a d e f	This paper reports the LD_{50} in 96 hours for 8 common inorganic salts. A synthetic dilution water of controlled hardness was prepared for use in the experiments. Among other variables, specific conductivity, as mhos at 20 C, was measured.	Trama (1954)
Sodium sulfate	*Lepomis macrochirus*	BCFA	–	12,500 (T4A)	a c e f	Test water was composed of distilled water with CP grade chemicals and was aerated.	Cairns and Scheier (1955)
Sodium sulfate	*Daphnia magna*	BSA	–	5,514 (O)	a c	The primary aim of this study was to determine the effects of lowered dissolved oxygen concentration upon an aquatic invertebrate when exposed to solutions of inorganic salts known to be present in various industrial effluents. Analysis of data conclusively shows the *D. magna* tested under lowered oxygen tension exhibited lower threshold values for the chemicals studied than when tested at atmospheric dissolved oxygen.	Fairchild (1955)
Sodium sulfate	*Gambusia affinis*	BSA	–	17,500 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Sodium sulfate	*Lepomis macrochirus*	BSA	–	12,500 (T4A)	a c d e i	A "control" was prepared by adding required chemicals to distilled water, and this was constantly aerated. Data reported are for larger fish, approximately 14.24 cm in length. Data for smaller fish are also in the report.	Cairns and Scheier (1959)
Sodium sulfate	*Pimephales promelas* (juveniles)	BSA	–	(S) 9,000-13,000 (T1-4A) (H) 13,500-14,000 (T1-4A)	a c d f	Syndets and soaps were of nearly equal toxicity in soft water (S) but syndets were approximately 40X more toxic than soap in hard water (H). The surfactant rather than the builder contained the toxicant.	Henderson, et al (1960)
Sodium sulphate	*Biomorpholaria a. alexandrina* *Bulinus truncatus* *Lymnaea caillaudi*	BSA	–	4,800 (K1A) 900 (K1A) 1,000 (K1A)	a	The degree of tolerance for vector snails of biharziasis to chemicals is somewhat dependent upon temperature. The temperatures at which (K1A) occurred was 27 C for *Bulinus* and *Lymnaea* and 26 C for *Biomorpholaria*.	Gohar and El-Gindy (1961)
Sodium sulfate	Hydropsychidae *Stenonema ares* *S. heterotarsale*	BCFA	–	320 (K 15%-4 da) 320 (K 50%-4 da) 320 (K 30%-4 da)	a c d e	Soft water used as diluent. Additional data are presented.	Surber and Thatcher (1963)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Sodium sulfate	Amphipoda	BSA	–	2,380 (T1A) 1,110 (T2A) 880 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
	Culex sp (larvae)			11,430 (T1A)			
	Daphnia magna (adult)			4,547 (T4A)			
	Daphnia magna (young)			6,800 (T1A)			
	Lepomis macrochirus			17,500 (T1A)			
	Lymnaea sp (eggs)			5,401 (T1A) 3,553 (T4A)			
	Mollienesia latopinna			20,000 (T1A) 15,996 (T2A)			
Sodium sulfate	*Nitzschia linearis*	BSA	–	1,900 (T5A)	a c e	The purpose of this experiment was to determine whether there was a constant relationship between the responses of these organisms. From the data presented, there was no apparent relationship of this type. Therefore the authors advise that bioassays on at least 3 components of the food web be made in any situation.	Patrick, et al (1968)
	Lepomis macrochirus			13,500 (T4A)			
Sodium sulfhydrate	*Oncorhyncus tshawytscha*	BSA	–	3.3 (K5)	a d e	This chemical is one of a number that may be found in Kraft mill waste effluents. Data are expressed as minimum lethal concentration for 5 days.	Haydu, et al (1952)
	Oncorhyncus kisutch			3.5 (K5)			
	Salmo clarkii clarkii			1.8 (K5)			
Sodium sulfide	*Daphnia magna*	BSA	–	9.4 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water.	Anderson (1946)
Sodium sulfide	*Gasterosteus aculeatus*	BSA	–	(O)	c e	Tap water was used to make up the solutions, which made up a pH of 6.8 with sulfuric acid. At a concentration of 0.0007N, the fish displayed much distress. At 0.00008N, the animal showed very little reaction. The test animal survived 72 hours in a solution of 0.0003N.	Jones (1948)
Sodium sulphide	*Oncorhyncus tshawytscha*	BSA	–	3.5 (K5)	a d e	This chemical is one of a number that may be found in Kraft mill waste effluents. Data are expressed as minimum lethal concentration for 5 days.	Haydu, et al (1952)
	Oncorhyncus kisutch			3.1 (K5)			
	Salmo clarkii clarkii			3.0 (K5)			
Sodium sulfide	*Gambusia affinis*	BSA	–	750 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)

Sodium sulfide	*Rasbora heteromorpha*	BSA	–	3.0 (O)	–	For many toxins the rate of mortality is found to be a linear function of the logarithm of the concentration of the poison; whereas the comparable relation between the logarithms of the survival time and the concentration is nonlinear. The linear function can be exploited to provide comparatively simple methods of estimating long-term survival concentrations. An application of this is suggested for defining realistic standards of toxicity. At the concentration listed for the chemical, the mean survival time was was 173 minutes.	Abram (1964)
Sodium sulfide	*Daphnia magna*	BSA	–	16 (T1A) 13 (T2A) 9 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Sodium sulfite	*Polycelis nigra*	BSA	–	0.048M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 6.8. Solutions were renewed every 12 hours.	Jones (1941)
Sodium sulfite	*Daphnia magna*	BSA	–	3,784 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Sodium sulfite	*Daphnia magna*	BSA	–	440 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water.	Anderson (1946)
Sodium sulfite	*Gambusia affinis*	BSA	–	2,600 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Sodium sulfite	*Daphnia magna*	BSA	–	299 (T1A) 273 (T2A) 203 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Sodium tartrate	*Polycelis nigra*	BSA	–	0.065M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 7.4 Solutions were renewed every 12 hours.	Jones (1941)
Sodium tartrate	*Daphnia magna*	BSA	–	<3,500 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water.	Anderson (1946)
Sodium thiocyanate	*Polycelis nigra*	BSA	–	0.012M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 9.6. Solutions were renewed every 12 hours.	Jones (1941)
Sodium thiocyanate	*Daphnia magna*	BSA	–	<11.3 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water.	Anderson (1946)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Sodium thiosulfate	*Polycelis nigra*	BSA	–	0.053M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 6.4. Solutions were renewed every 12 hours.	Jones (1941)
Sodium thiosulfate	*Daphnia magna*	BSA	–	<520 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water. Value may be only half of that reported.	Anderson (1946)
Sodium thiosulfate	*Gambusia affinis*	BSA	–	26,000 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Sodium thiosulfate	*Daphnia magna*	BSA	–	2,245 (T1A) 1,223 (T2A) 805 (T4A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Sodium dibasic phosphate	*Daphnia magna*	BSA	–	<59 (O)	–	This assay is based on concentration of the chemical required to immobilize the test animal. Assays were conducted in centrifuged Lake Erie water. Value may be only half of that reported.	Anderson (1946)
Sodium tribasic phosphate	*Daphnia magna*	BSA	–	<52 (O)	–	Comment same as above. Toxic effect may be the result of the precipitate formed which may obstruct the straining mechanism of the *Daphnia*.	Anderson (1946)
Sodium triphosphate	*Gambusia affinis*	BSA	–	467 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Sodium tripoly-phosphate	*Pimephales promelas* (juveniles)	BSA	–	(S) 400 (T1-4A) (H) 1,300-1,350 (T1-4A)	a c d f	Syndets and soaps were of nearly equal toxicity in soft water (S) but syndets were approximately 40X more toxic than soap in hard were (H). The surfactant rather than the builder contained the toxicant. Additional data are given.	Henderson, et al (1959)
Sodium valerate	*Lepomis macrochirus*	BSA	–	5,000 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Stannic chloride	*Daphnia magna*	BSA	–	146 (O)	a	Lake Erie water was used as diluent. Toxicity given as threshold concentration producing immobilization for exposure periods of 64 hours.	Anderson (1948)
Stannous chloride	*Daphnia magna*	BSA	–	<25 (O)	a	Comment same as above.	Anderson (1948)
Strontium chloride	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, possible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compares this work with earlier work, and lists an extensive bibliography. In 0.237N solution, fish survived 168 minutes.	Powers (1918)

Strontium chloride	*Daphnia magna*	BSA	–	114 (O)	a	Lake Erie water was used as diluent. Toxicity given as threshold concentration producing immobilization for exposure periods of 64 hours.	Anderson (1948)
Strontium nitrate	*Carassius carassius*	BSA	–	(O)	a	This old, lengthy paper discusses toxicity of many chemicals, possible mechanism of action of some, the effect of temperature, effect of dissolved oxygen, the efficiency of the goldfish as a test animal, compares this work with earlier work, and lists an extensive bibliography. In 0.155N solution, fish survived 300 minutes.	Powers (1918)
Strontium nitrate	*Gasterosteus aculeatus*	BSA	–	0.2 (K10)	–	Solutions were made up in tap water. 3.0 to 5.0-cm stickleback fish were used as experimental animals. This paper points out that there is a marked relationship between the toxicity of the metals and their solution pressures. Those with low solution pressures were the most toxic.	Jones (1939)
Styrene	*Pimephales promelas*	BSA	–	51 (T4A)	a c d e f	Most fish survived at test concentrations of about one half, or slightly more, of the TL_m value. No attempt was made to estimate 100 percent survival.	Pickering and Henderson (1966)
	Lepomis macrochirus			22 (T4A)			
	Carassius auratus			68 (T4A)			
	Lebistes reticulatus			68 (T4A)			
4-styryl-pyridine	*Petromyzon marinus* (larvae)	BSA	–	10 (NTE)	a	Additional data are presented.	Piavis (1962)
Sulfide	*Polycelis nigra*	BSA	–	0.00045M (L2)	c	This is part of a report listing 27 anions and their toxicities on a planarian. Mode of action of the anions is discussed. Water distilled in glass was used to prepare the solutions. The pH of this solution was 6.6. Solutions were renewed every 12 hours.	Jones (1941)
Sulfoxide	*Pimephales promelas*	BSA	–	0.74 (T4A)	a c d f g	Test water was spring water diluted with distilled water. Removal of toxic chemicals by carbon adsorption, chlorine and chlorine dioxide treatment, and alum coagulation was studied. The most effective method to remove fish poisons was by use of activated charcoal adsorption.	Cohen, et al (1961)
Sulfur	*Gambusia affinis*	BSA	–	10,000 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al
Sulfur (colloidal)	*Carassius carassius*	BSA	–	(O)	a	Sulfur concentrations were toxic from 0.016 to 0.210 percent. Survival time is reported in minutes, from 45 to 315.	Harukawa (1922-23)
Sulfur, lime	*Simocephalus serrulatus*	BSA	–	11.0 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 48 hours. Data cited are for 60 F, but assays were performed at varied temperatures. "Water Chemistry" (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
	Daphnia pulex			10.0 (SB)			

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Sulfuric acid	*Daphnia magna*	BSA	–	88 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Sulfuric acid	*Gambusia affinis*	BSA	–	42 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Sulfuric acid	Sewage organisms	BOD	–	58 (TC_{50})	a	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Tannic acid	*Daphnia magna*	BSA	–	<26 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Tannic acid	*Gambusia affinis*	BSA	–	41 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Tannic acid	Sewage organisms	BOD	–	(NTE)	–	The purpose of this paper was to devise a toxicity index for industrial wastes. Results are recorded as the toxic concentration producing 50 percent inhibition (TC_{50}) of oxygen utilization as compared to controls. Five toxigrams depicting the effect of the chemicals on BOD were devised and each chemical classified.	Hermann (1959)
Tartaric acid	*Daphnia magna*	BSA	–	135 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)

Terpine alcohol (85 percent pine oil)	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with numbers of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – T (3) Ma – PT (14) So – NT Cv – T (3) Gp – T (3) Np – NT	Palmer and Maloney (1955)
2-tertiary-butyl-4,6 dinitrophenol	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Comment same as above except Cl – NT Ma – NT So – NT Cv – PT (7) Gp – NT Np – PT	Palmer and Maloney (1955)
1,2,3,4-tetrachlorobenzene	*Australorbis glabratus*	BSA and FL	Puerto Rico	Failed	c	Seven of the tested compounds failed to meet acceptability criteria – that is, complete kill after 6-hr exposure to 10 ppm. They were not used in field tests. Field tests showed WL 8008 to be highly effective.	Seiffer and Schoof (1967)
Tetrachlorohydroquinone	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	The chemical was tested on a 5-day-old algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume, Chu No. 10 medium was used.	Fitzgerald, et al (1952)
Tetramethyl-p-phenylenediamine hydrochloride	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	Comment same as above.	Fitzgerald, et al (1952)
2',3',4'-5-tetranitrobenzanilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	10 (K2) (O)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule. At 10 ppm the chemical was not toxic to goldfish.	Walker, et al (1966)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Thiocarbamide	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – NT Ma – PT (14) So – PT (14) Cv – PT (14) Gp – PT (7) Np – PT (7)	Palmer and Maloney (1955)
Titanium sulfate	*Pimephales promelas*	BSA	–	(H) 120 (T4A) (S) 8.2 (T4A)	a c d f	Both hard (H) and soft (S) water were used.	Tarzwell and Henderson (1960)
Toluene	*Pimephales promelas*	BSA	–	44 (T4A)	a c d e f	Most fish survived at test concentrations of about one half, or slightly more, of the TL_m value. No attempt was made to estimate 100 percent survival.	Pickering and Henderson (1966)
	Lepomis macrochirus			24 (T4A)			
	Carassius auratus			62 (T4A)			
	Lebistes reticulatus			66 (T4A)			
Toluene	*Gambusia affinis*	BSA	–	1,260 (T2A)	a c d e g	The effect of turbidity on the toxicity of the chemicals was studied. Test water was from a farm pond with "high" turbidity. Additional data are presented.	Wallen, et al (1957)
Tribromophenol	Bacteria (sewage)	BSA	–	97 (O)	e	In the halophenols, the ortho was less toxic than the meta or para. All of the monohalophenols were less toxic than the 2,4,6-trihalophenols. Some data on biodegradability of halophenols were presented. The figure reported is for a TL_m value for cumulative gas production for 7 days.	Ingols and Gaffney (1956)
Tri-n-butylamine	*Semotilus atromaculatus*	BSA	–	20 to 40 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hours and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
Tri-n-butyltin acetate	*Australorbis glabratus*	BSA and FL	Puerto Rico	Failed	c	Seven of the tested compounds failed to meet acceptability criteria – that is, complete kill after 6-hr exposure to 10 ppm. They were not used in field tests. Field tests showed WL 8008 to be highly effective.	Seiffer and Schoof (1967)
bis-(tri-n-butyltin) oxide	*Australorbis glabratus*	BSA and FL	Puerto Rico	0.41-0.84 (L)	c	Comment same as above.	Seiffer and Schoof (1967)

1,2,4-trichloro-benzene		BSA	–		a	Experiments were conducted in standing water. Results were rated on a scale of 0 to 10, 0 standing for no toxic effect and 10 signifying a complete kill. Evaluation was based on visual observation of the plant response at weekly intervals for 4 weeks.	Frank, et al (1961)
	Elodea canadensis			5 (O)		No toxic effect.	
				100 (O)		Injury rating of 9.5.	
	Potamogeton nodosus			5 (O)		No toxic effect.	
				100 (O)		Injury rating of 9.8.	
	Potamogeton pectinatus			5 (O)		No toxic effect.	
				100 (O)		Injury rating of 9.8.	
1,1,1-trichloro-ethane	*Lagodon rhomboides*	BSA	–	75-100 (O)	–	Experiments were conducted in aerated salt water. Toxicity range given as the concentrations which produced <1/2 deaths and >1/2 deaths.	Garrett (1957)
1,1,2-trichloro-ethane	*Lagodon rhomboides*	BSA	–	150-175 (O)	–	Comment same as above.	Garrett (1957)
Trichloro-phenol	Bacteria (sewage)	BSA	–	60 (O)	e	In the halophenols, the ortho was less toxic than the meta or para. All of the monohalophenols were less toxic than the 2,4,6-trihalophenols. Some data on biodegradability of halophenols were presented. The figure reported is for a TL_M value for cumulative gas production for 7 days.	Ingols and Gaffney (1965)
Trichloro-toluene	*Elodea canadensis*	BSA	–	5 (K 4 wk) 100 (K 4 wk)	a	Experiments were conducted in standing water. Results were rated on a scale of 0 to 10, 0 standing for no toxic effect and 10 signifying a complete kill. Evaluation was based on visual observation of the plant response at weekly intervals for 4 weeks.	Frank, et al (1961)
	Potamogeton nodosus			5 (O)		Injury rating of 8.4.	
				100 (O)		Injury rating of 9.1.	
	Potamogeton pectinatus			5 (O)		Injury rating of 8.5.	
				100 (O)		Injury rating of 9.5.	
3,4,6-trichloro-2-nitrophenol (free phenol)	*Petromyzon marinus*	BSA	–	5 (K 100%)	a	Mortality occurred in approximately 24 hours. This was a study on controlling sea lamprey larvae.	Ball (1966)
	Salmo gairdnerii			17 (K 10%)			
	S. trutta			15 (K 10%)			
3,4,6-trichloro-2-nitrophenol	*Petromyzon marinus*	BSA	–		a	Additional data are presented.	Piavis (1962)
	(prolarvae)			10 (K15)			
	(larvae)			10 (K1)			

Chemical	Organism	Bioassay or Field Study$^{(1)}$	Field Location$^{(2)}$	Toxicity, Active Ingredient, ppm$^{(3)}$	Experimental Variables Controlled or Noted$^{(4)}$	Comments	Reference (Year)
3,4,6-trichloro-2-nitrophenol (Na salt)	*Petromyzon marinus* (larvae)	BSA FS	– Mich.	13 (K 100%) 12 (K 100%)	a	Mortality occurred in approximately 24 hours. This was a study on controlling sea lamprey larvae. The "field" study involved use of simulated lake water in large raceways.	Applegate (1958)
	Salmo gairdnerii (fingerlings)	BSA FS		23 (K 10%) 40 (NTE)			
	S. trutta	FS		40 (NTE)			
	Salvelinus fontinalis	FS		40 (NTE)			
	Ambloplites rupestris	FS		40 (NTE)			
	Lepomis gibbosus	FS		40 (NTE)			
	Coesius plumbeus	FS		40 (NTE)			
	Semotilus atromaculatus	FS		40 (NTE)			
	Percina caprodes	FS		40 (NTE)			
	Cambarus spp	FS		40 (NTE)			
	Aquatic larvae	FS		40 (NTE)			
	Catostomus commersoni	FS		32 (NTE)			
	Ictalurus melas	FS					
	I. nebulosus	FS		20 (K)			
	Perca flavescens	FS		32 (NTE)			
2',4',6'-trichloro-3-nitrosalicylanilide	*Salmo gairdnerii*	BSA	–	10 (K 3 hr)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule.	Walker, et al (1966)
	Carassius auratus			10 (K2)			
Triethylamine	*Semotilus atromaculatus*	BSA	–	50 to 80 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hours and above which all test fish died. Additional data are presented.	Gillette, et al (1952)

3-trifluoro-methyl-4-nitrophenol	*Petromyzon marinus* *Salmo gairdnerii*	BSA	–	2 (K 100%) 7 (K 10%)	a	Mortality occurred in approximately 24 hours. This was a study on controlling sea lamprey larvae.	Applegate (1958)
3-trifluoro-methyl-4-nitrophenol	*Petromyzon marinus* (larvae)	BSA	–	10 (K 1-2 hr)	a	Additional data are presented.	Piavis (1962)
a,a,a-trifluoro-4-nitro-m-cresol	*Salmo gairdnerii*	BSA	–	9 (K 10%)	a	Mortality occurred in approximately 24 hours.	Applegate (1958)
	S. trutta	BSA		7 (K 19%)	a		
Triiodophenol	Bacteria (sewage)	BSA	–	83 (O)	e	In the halophenols, the ortho was less toxic than the meta or para. All of the monohalophenols were less toxic than the 2,4,6-trihalophenols. Some data on biodegradability of halophenols were presented. The figure reported is for a TL_M value for cumulative gas production for 7 days.	Ingols and Gaffney (1965)
2,2,4-trimethyl (β-phenyliso-propyl)-1,2-dihydro-quinoline	*Daphnia magna*	BSA	–	1.8 (K2)	a	An attempt was made to correlate the biological action with the chemical reactivity of selected chemical substances. Results indicated a considerable correlation between the aquarium fish toxicity and antiautocatalytic potency of the chemicals in marked contrast to their toxicity on systemic administration.	Sollman (1949)
Trimethyl and trimethyl-octadecadienyl ammonium chlorides	*Cylindrospermum licheniforme (Cl)* *Gleocapsa sp (G)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – NT G – NT So – PT Cv – NT Gp – NT Np – NT	Palmer and Maloney (1955)
3,3',5-tri-nitrobenz-anilide	*Salmo gairdnerii* *Carassius auratus*	BSA	–	10 (K 3 hr) (O)	a	This paper deals with the relations between chemical structures of salicylanilides and benzanilides and their toxicity to rainbow trout and goldfish. The chemical structure of salicylanilides and benzanilides was related to toxicity and selectivity to rainbow trout and goldfish. Salicylanilides were more toxic than benzanilides to the fishes. The ortho hydroxy substitution of salicylanilide accelerated biological activity against fish. Meta nitro substitution on the salicylanilides and benzanilides increased toxicity to fish. Similar findings are reported for halogens and their relative position(s) in the molecule. At 10 ppm the chemical was not toxic to goldfish.	Walker, et al (1966)
Trinitro-toluene	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75-ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
2,3,5-tri-phenyltetra-zolium chloride	*Microcystis aeruginosa*	L	–	2.5 (K)	a, etc	Comment same as above.	Fitzgerald, et al (1952)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Triphenyltin acetate	*Australorbis glabratus*	BSA	Puerto Rico	(O)	c	Seven of the tested compounds failed to meet acceptability criteria – that is, complete kill after 6-hr exposure to 10 ppm. They were not used in field tests. Field tests showed WL 8008 to be highly effective.	Seiffer and Schoof (1967)
Triphenyltin chloride	*Australorbis glabratus*	BSA	Puerto Rico	(O)	c	Comment same as above.	Seiffer and Schoof (1967)
Tri-n-propylamine	*Semotilus atromaculatus*	BSA	–	30 to 70 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hours and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
Tri-n-propyltin oxide	*Australorbis glabratus*	BSA	Puerto Rico	(O)	c	Seven of the tested compounds failed to meet acceptability criteria – that is, complete kill after 6-hr exposure to 10 ppm. They were not used in field tests. Field tests showed WL 8008 to be highly effective.	Seiffer and Schoof (1967)
Trypaflavine (acriflavine neutral)	*Ictalurus punctatus*	BSA	–	17.9 (K2) 11.5 (T2A)	a c f i	The experiment was conducted at 66 C.	Clemens and Sneed (1958)
Uranyl acetate	*Pimephales promelas*	BSA	–	(S) 3.7 (T4A)	a c d f	Both hard (H) and soft (S) water were used.	Tarzwell and Henderson (1960)
Uranyl nitrate	*Pimephales promelas*	BSA	–	(S) 3.1 (T4A)	a c d f	Comment same as above.	Tarzwell and Henderson (1960)
Uranyl sulfate	*Pimephales promelas*	BSA	–	(H) 135 (T4A) (S) 2.8 (T4A)	a c d f	Comment same as above.	Tarzwell and Henderson (1960)
Urea	*Semotilus atromaculatus*	BSA	–	16,000 to 30,000	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hours and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
Valeric acid	*Daphnia magna*	BSA	–	45 (T2A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Vanadium pentoxide	*Pimephales promelas*	BSA	–	(H) 55 (T4A) (S) 13 (T4A)	a c d f	Both hard (H) and soft (S) water were used.	Tarzwell and Henderson (1960)
Vanadyl sulfate	*Pimephales promelas* *Lepomis macrochirus*	BSA	–	(H) 30 (T4A) (S) 4.8 (T4A) (H) 55 (T4A) (S) 6 (T4A)	a c d f	Comment same as above.	Tarzwell and Henderson (1960)

Vanillin	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – NT Ma – NT So – PT (3) Cv – PT (3) Gp – T (3), PT (21) Np – PT (7)	Palmer and Maloney (1955)
Vinyl acetate	*Pimephales promelas*	BSA	–	22 (T4A)	a c d e f	Most fish survived at test concentrations of about one half, or slightly more, of the TL_m value. No attempt was made to estimate 100 percent survival.	Pickering and Henderson (1966)
	Lepomis macrochirus			18 (T4A)			
	Carassius auratus			42 (T4A)			
	Lebistes reticulatus			26 (T4A)			
Xanthic acid, ethyl sodium salt	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – NT Ma – PT (7) So – NT Cv – PT (7) Gp – NT Np – NT	Palmer and Maloney (1955)
Xylene	*Daphnia magna*	BSA	–	100 1000 (T1A)	a c	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water.	Dowden and Bennett (1965)
Xylene	*Pimephales promelas*	BSA	–	21 (T4A)	a c d e f	Most fish survived at test concentrations of about one half, or slightly more, of the TL_m value. No attempt was made to estimate 100 percent survival.	Pickering and Henderson (1966)
	Lepomis macrochirus			22 (T4A)			
	Carassius auratus			24 (T4A)			
	Lebistes reticulatus			39 (T4A)			
Zinc	*Salmo gairdnerii*	BSA	–	6 (K2)	a e	The concentration given was fatal to fingerlings. Young fish 2 and 4 weeks old could not tolerate concentrations of 4 ppm, but with increasing age showed a tendency to develop a tolerance to solutions of this concentration.	Goodman (1951)
Zinc	Sewage organisms	BOD	–	(O)	–	Zinc was toxic to sewage organisms in concentrations as low as 0.001 ppm. This could result in errors in BOD tests. At 1.0 ppm, the oxygen demand in percent of the control was 83%.	Ingols (1956)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Zinc	*Lepomis macrochirus* (adult)	BSA	–	18 C (H) 10.1-12.5 (T4A) (S) 2.9-3.8 (T4A) 30 C (H) 10.2-12.2 (T4A) (S) 1.9-3.6 (T4A)	a c d e f i n g	The results of these experiments indicated that in dilution water of the same quality there was little difference in toxicity at 18 C and 30 C. A considerable difference in toxicity was apparent between hard (H) and soft (S) water. A greater amount of zinc in solution was required in hard water than in soft water. Hardness of the dilution water had a greater effect upon the toxicity of zinc than did temperature.	Cairns and Scheier (1958)
Zinc	*Salmo salar*	BCFA	–	0.042 (T1A)	a c f	The laboratory water in which the experiment was performed contained 3 µl/liter of zinc, as judged by analysis over several years, and 2 µg/liter of copper. Lethal concentrations of mixtures acted two or three times as fast as the metals singly, a somewhat greater potentiation than was found in the previous tests with salmon.	Schoenthal (1963)
Zinc	*Lepomis macrochirus* *Lepisosteus osseus* *Dorosoma petenense* *Dorosoma cepedianum* *Alosa chrysochloris* *Cyprinus carpio* *Carassius auratus*	BCFA	–	0.0-5.0 (O)	a c f	An autopsy method for acute zinc toxicity in fish was developed. Thirty to 90-day exposures to sublethal concentrations indicated that the opercular bone accumulates zinc at the same rate as gill tissue. By using the ratio of zinc in the gill to zinc in the bone a reasonably constant value was obtained by nonlethal exposures. This value increased up to a hundredfold in acute exposures.	Mount (1964)
Zinc	*Lepomis macrochirus*	BSA	–	2.86-3.78 (O)	a f	At the given concentration 50% survival occurred at 18 C in soft water.	Cairns (1965)
				0.90-2.10 (O)		At the given concentration 50% survival occurred at 30 C in soft water.	
				6.60-9.47 (O)		At the given concentration 50% survival occurred at 18 C in hard water.	
				6.18-9.50 (O)		At the given concentration 50% survival occurred at 30 C in hard water.	
Zinc	Rainbow trout	FR	Scotland	3.9 (T2)	a c e f l m	This work represents an extension of laboratory studies of the toxicity of complex effluents to investigations of rivers.	Herbert, et al (1965)

Zinc	*Pimephales promelas*	BSA	–	(O)	a c d	Zinc sulfate was added to tap water for the experiments. TL_m values for minnow eggs: 1 day – 3.95 ppm 2 day – 2.55 ppm 4 day – 1.83 ppm 7 day – 1.71 ppm 12 day – 1.63 ppm TL_m values for minnow fry: 1 day – 0.95 ppm 2 day – 0.95 ppm 4 day – 0.87 ppm 7 day – 0.87 ppm From the experimental data, it appeared that animals exposed to a dilute zinc solution developed a tolerance to this metal. The duration of the tolerance was not investigated.	Pickering and Vigor (1965)
Zinc	Fathead minnow	BCFA	–	4.9 to 32.3 (T4A)	a c d e	Zinc was most toxic at a pH of 8.0 and a water hardness of 50 ppm and least toxic at pH 6.0 and a hardness of 200 ppm. At any given hardness, zinc was always more toxic at a high pH than at a low pH. The results are in disagreement with most published work possibly because a flow-through system would keep any precipitated zinc in suspension. The first value reported is for a pH of 8.0 and a hardness of 50, and the second for a pH of 6.0 and a hardness of 200.	Mount (1966)
Zinc	*Fundulus heteroclitus*	BSA	–	157-180 (K)	a c e i	Fish subjected to the concentration reported died in 24 to 48 hours. The dead fish contained 7 and 8 times more zinc in the whole fish and in the gill arch than untreated control fish.	Eisler (1967)
Zinc	*Lebistes reticulatus* *Bufo valliceps* (tadpoles) *Daphnia magna*	L	–	10.0 (K) 10.0 (K) 1.0 (K)	a c e	It is assumed in this experiment that the cations considered are toxic because they combine with an essential sulfhydryl group attached to a key enzyme. This treatment indicates that the metals which form the most insoluble sulfides are the most toxic. The log of the concentration of the metal ion is plotted against the log of the solubility product constant of the metal sulfide – a treatment that does not lend itself to tabulation. The cation toxicity cited is only an approximate concentration interpolated from a graph. Time of death was not specified.	Shaw and Grushkin (1967)
Zinc	*Gasterosteus aculeatus*	BSA	–	0.1 (O)	a c e	This is a discussion of a bioassay method using stickleback fish and spectrophotometric determinations of the chemicals evaluated. The number listed is said to be the "toxic limit" for the fish.	Hawksley (1967)
Zinc	*Lebistes reticulatus* (guppy)	BSA	–	(O)	a c f n o	A series of equations was devised to describe the toxicity of a system containing two toxicants – zinc and cyanide. A concentration of 1 ppm of Zn killed 50% of the fish in 32 hours. 0.75 ppm killed 50% in 63 hours, and 0.56 ppm killed 50% in 96 hours. Toxicity of the two-component system was then determined using varying ratios of the two components.	Chen and Selleck (1968)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Zinc	*Lepomis macrochirus*	BCFA	–	7.2-12.0 (T20CF)	a c d e f	The toxicity of zinc was largely dependent upon the dissolved oxygen in the water. Bluegills showed an increased mortality to zinc as a result of an environmental stress of low dissolved oxygen concentration. The lowest toxic zinc concentration was for a system containing 1.8 mg/l of dissolved oxygen, and the highest for a system containing 5.6 mg/l.	Pickering (1968)
Zinc	*Salmo gairdnerii*	BSA	–	2.8-3.5 (T4A)	a c d e f o	The concentration killing a half batch of fish in 2 days provides a reasonable estimate of the threshold concentration. The lethality of this chemical depends upon the total hardness of the water and the dissolved oxygen concentration.	Brown (1968)
Zinc	*Oncorhynchus kisutch*	BSA	–	(O)	a c	Zinc uptake and distribution in the developing coho salmon egg was measured using radioisotope tracer techniques. About 70% of the total accumulated zinc was bound rather firmly to the chorion, 26% was found in the perivitelline fluid, 2% in the yolk, and 1% in the embryo.	Wedemeyer (1968)
Zinc (Zn^{++})	*Lepomis macrochirus*	BSA	–	4.2 (T4A)	a c d e	All fish were acclimatized for 2 weeks in a synthetic dilution water.	Cairns and Scheier (1968)
Zinc and copper	Atlantic salmon	FR	Canada	(O)	f	"Toxicity index" for zinc and copper combined was described in connection with disturbed salmon migration. Toxicity index $>$1.0 indicates lethality to "young salmon after long exposure". A toxicity index of 0.15 or 15% of the lethal concentration of zinc and copper seems to be the maximum safe level for migration.	Sprague (1964)
Zinc and copper	*Salmo salar*	BSA	–	0.048 Cu (O) 0.600 Zn	a	The values given are for an ILL (incipient lethal level) and in this instance only in water of 20 mg/liter of hardness. Concentrations above this are lethal in about one day. These values were determined by bioassay. Salmon parr in the laboratory avoided less than one tenth of incipient lethal levels. Avoidance thresholds were 0.09 ILL of zinc, 0.05 ILL of copper and 0.02 ILL of equitoxic mixtures. In equitoxic mixtures of these compounds, the ILL was additive.	Sigler, et al (1966)
Zinc acetate	*Pimephales promelas*	BSA	–	(S) 0.88 (T4A)	c d e f	(S) Soft water. Values are expressed as mg/l of metal.	Pickering and Henderson (1965)
Zinc borofluoride	Sewage organisms	BOD	–	55 (O)	–	Various metal salts were studied in relation to how they affected the BOD of both raw and treated sewage as well as how they affected the processing of sewage in the treatment plant. BOD was used as the parameter to measure the effect of the chemical. The chemical concentration cited is the ppm required to reduce the BOD values by 50%. This chemical was tested in an unbuffered system.	Sheets (1957)

Zinc chloride	*Daphnia magna*	BSA	–	<<0.15 (S)	a	Lake Erie water was used as diluent. Toxicity given as threshold concentration producing immobilization for exposure periods of 64 hours.	Anderson (1948)
Zinc chloride	*Lepomis macrochirus*	BCFA	–	6.91 (T4A)	a c e f	Test water was composed of distilled water with CP grade chemicals and was aerated throughout the 96-hour exposure period.	Cairns and Scheier (1955)
Zinc chloride	*Lepomis macrochirus*	BSA	–	20 (T4A)	a c e	Increase in temperature seemed to increase toxicity of this chemical. Low dissolved oxygen reduced toxicity of some chemicals in this study. Toxicity values may be 20% higher in hard versus soft water.	Cairns (1957)
Zinc chloride (as Zn^{++})	*Lepomis macrochirus*	BSA	–	(N) 8.02 (T4A) N (L) 4.9 (T4A) L	a e	Modified Chu No. 14 test medium was used. Toxicity is given both for "normal" O_2 (5-9 ppm), (N), and with "low" O_2 (2 ppm DO), (L). High and low threshold concentration percent of survival are also presented.	Cairns and Scheier (1958)
Zinc chloride	*Lepomis macrochirus*	BSA	–	6.91 (T4A)	a c d e i	A "control" was prepared by adding required chemicals to distilled water, and this was constantly aerated. Data reported are for larger fish, approximately 14.24 cm in length. Data for smaller fish are also in the report.	Cairns and Scheier (1959)
Zinc chloride (tagged with zinc 35)	*Ictalurus nebulosus*	BS	–	(O)	c d f i l	Bullheads showed an initial rapid uptake of zinc for the first several hours followed by a short period of decline. Z^{35} was used to measure zinc uptake. The fish exposed to 6.0 ppm of zinc for 96 hours, when placed in flowing, fresh water, lost 43 percent of their total accumulated zinc after 1 day. Fish exposed to 12 ppm of zinc for 14 days all survived.	Joyner (1961)
Zinc chloride (as Zn^{++})	*Brachydanio rerio* (adults) (eggs) *Lepomis macrochirus*	BSA	–	 28 (T2A) 105 (T2A) 5.2 (T2A)	a c d e f	The test dilutions were made up from distilled water and ACS grade chemicals. Temperature was held at 24 C and the solution was aerated to maintain a dissolved oxygen content of 5-9 ppm.	Cairns, et al (1964)
Zinc chloride	*Lepomis macrochirus*	BSA	–	(S) 5.37 (T4A)	c d e f	(S) Soft water. Values are expressed as mg/l of metal.	Pickering and Henderson (1965)
Zinc chloride	*Nitzschia linearis* *Physa heterostropha* *Lepomis macrochirus*	BSA	–	4.3 (T5A) 0.79-1.27 (T4A) 2.86-3.78 (T4A)	a c e	The purpose of this experiment was to determine whether there was a constant relationship between the responses of these organisms. From the data presented, there was no apparent relationship of this type. Therefore the authors advise that bioassays on at least 3 components of the food web be made in any situation.	Patrick, et al (1968)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Zinc-copper-cyanide complex	*Pimephales promelas*	BSA	–	1.0 ppm Zn 0.025 ppm Cu 0.05 ppm CN (non-toxic 4 days) 1.0 ppm Zn 0.25 ppm Cu 0.33 ppm CN (non-toxic 4 days) 1.0 ppm Zn 0.025 ppm Cu (K < 14 hr)	a c	Synthetic soft water used.	Doudoroff, et al (1956)
Zinc cyanide	Sewage organisms	BOD	–	0.75 (O)	–	Various metal salts were studied in relation to how they affected the BOD of both raw and treated sewage as well as how they affected the processing of sewage in the treatment plant. BOD was used as the parameter to measure the effect of the chemical. The chemical concentration cited is the ppm required to reduce the BOD values by 50%. This chemical was tested in an unbuffered system.	Sheets (1957)
Zinc cyanide complex	*Lepomis macrochirus* (juveniles)	BSA	–	0.4 (O)	a c d f p	For the concentration given, the median resistance time in minutes was 256.	Doudoroff, et al (1966)
Zinc (a)-cyanide (b) mixture	*Lepomis macrochirus*	BSA	–	(a) 3.90 (T4A) (b) 0.26 (T4A)	a c d e	All fish were acclimatized for 2 weeks in a synthetic dilution water.	Cairns and Scheier (1968)
Zinc cyanide complex [sodium cyanide (564 ppm CN⁻) and zinc sulfate (394 ppm Zn)]	*Pimephales promelas*	BSA	–	0.18 (T4A)	a c	Synthetic soft water was used. Toxicity data given as number of test fish surviving after exposure at 24, 48, and 96 hr. TL_m values were estimated by straight-line graphical interpolation and given in ppm CN^-.	Doudoroff, et al (1956)
Zinc dimethyl-dithio-carbamate	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – PT (7) Ma – T (7), PT (14) So – NT Cv – PT (14) Gp – T (14) Np – T (3)	Palmer and Maloney (1955)

Zinc dimethyl-dithio-carbamate (100 percent)	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Comment same as above except that: Cl – T (3) Ma – T (3) So – T (3) Cv – T (3) Gp – T (3) Np – T (3)	Palmer and Maloney (1955)
Zinc ion	*Physa heterostropha*	BSA	–	20 C (S) 0.79-1.27 (T4A) (H) 2.66-5.57 (T4A) 30 C (S) 0.62-0.78 (T4A) (H) 2.36-6.36 (T4A)	a c d e q	The objective of these experiments was to determine the effects of water temperature and hardness on the toxicity of zinc ion to pond snails. (H) = hard water, (S) = soft water.	Cairns and Scheier (1958)
Zinc ion	Fish	BSA	–	1.5×10^{-4} M (K)	a c	Avoidance behavior of test fish to toxic chemicals is given. Toxicity is given as the lowest lethal concentration (molar). Ratios of avoidance and lowest lethal concentration are presented and discussed.	Ishio (1965)
Zinc-nickel cyanide complex	*Pimephales promelas*	BSA	–	1.0 ppm CN^- 0.6 ppm Zn (K $<$ 16 hr) 0.13 ppm Ni	a c	Synthetic soft water was used. Toxicity data given as number of test fish surviving.	Doudoroff, et al (1956)
Zinc nitrate	*Balanus balanoides*	BSA	–	32.0 (O)	–	The concentration listed was lethal to 90% of adult barnacles in 2 days.	Clarke (1947)
Zinc salts	Diatoms Platyhelminths Many insects	FR	Ystwyth, Wales	0.2-0.7 (O)	–	Zinc salts were from mine drainage. The flora above the mines was rich, but below the sources of pollution was poor in quantity and variety of lithophilous insects.	Jones (1958)
Zinc salts	*Salmo gairdnerii*	BSA	–	(O)	a e	This is a study of the effect of varying dissolved oxygen concentrations on the toxicity of selected chemicals. The toxicity of heavy metals, ammonia, and monohydric phenols increased as the dissolved oxygen in water was reduced. The most obvious reaction of fish to lowered oxygen content is to increase the volume of water passed over the gills, and this may increase the amount of poison reaching the surface of the gill epithelium. The concentration of the chemical in the water was not specified.	Lloyd (1961)
Zinc stearate	*Lepomis macrochirus*	BSA	–	(O)	–	"Standard reference water" was described and used as well as lake water. Varied results were obtained when evaluations were made in various types of water. Compound is very slightly soluble in water. No toxicity data given.	Dowden and Bennett (1965)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Zinc sulfate	*Gasterosteus aculeatus*	BSA	–	0.7 (TL4½A)	a c	Death of the fish resulted from an interaction between the metallic ion and the mucus secreted by the gills. Coagulated mucus formed on the gill membranes and impaired respiration to such a degree that the fish asphyxiated. The addition of 50 mg/l of calcium chloride to the tank protected against the toxic effect of this metal salt.	Jones (1939)
Zinc sulfate	*Daphnia magna*	BSA	–	<48 (O)	a c	This paper deals with the toxicity thresholds of various substances found in industrial wastes as determined by the use of *D. magna*. Centrifuged Lake Erie water was used as a diluent in the bioassay. Threshold concentration was defined as the highest concentration which would just fail to immobilize the animals under prolonged (theoretically infinite) exposure.	Anderson (1944)
Zinc sulfate	*Salmo gairdnerii*	BSA	–	25 ppm (0, 133 min)	a c e f	Tap or distilled water used as diluent. Toxicity defined as the average time when the fish lost equilibrium when exposed to the test chemical (ppm Zn).	Grindley (1946)
Zinc sulfate	*Pygosteus pungitius*	BCF	–	(O)	a c	Fish were exposed to 0.04, 0.003, 0.0003, and 0.0001N zinc sulfate. Survival times at these concentrations were, respectively: 85 minutes, 190 minutes, 7 hr, and 15 hr.	Jones (1947)
Zinc sulfate	Sewage organisms	BOD	–	920 (O)	–	Various metal salts were studied in relation to how they affected the BOD of both raw and treated sewage as well as how they affected the processing of sewage in the treatment plant. BOD was used as the parameter to measure the effect of the chemical. The chemical concentration cited is the ppm required to reduce the BOD values by 50%. This chemical was tested in an unbuffered system.	Sheets (1957)
Zinc sulfate	*Salmo gairdnerii*	BSA	–	(O)	a c	Zinc sulfate was less toxic in hard water than in soft water; more toxic in hard water with increased temperature; and more toxic when DO decreased. Survival curves are presented.	Lloyd (1960)
Zinc sulfate (as Zn)	Rainbow trout	BSA	–	(O)	a c d	The 48-hour LD_{50} as interpolated from a graph was 4 ppm. A method for prediction of toxicity of spent liquor from a coke oven before and after biological treatment is briefly discussed.	Herbert (1961)
Zinc sulfate	*Tendipes decorus* *Limnodrilus hoffmeisteri* *Physa heterostropha* *Asellus communis* *Argia* sp	BSA	–	56 (K 40%) 10 (T4A) 14 (T4A) 38.5 (T4A) 56 (T4A)	a c d i	Kill data for *T. decorus* is presented on other concentrations in either hard or soft water.	Wurtz and Bridges (1961)
Zinc sulfate	*Lebistes reticulatus*	BSCH	–	5.0 (41% K 90)	a c d e	Sublethal effects found were retarded growth, increased mortality, and delayed sexual maturity.	Crandall and Goodnight (1962)

Zinc sulfate	*Physa heterostropha* *Helisoma companulata*	BSA	–	4.2 (T1A)* 1.9 (T2A) 1.9 (T3A) 1.9 (T4A) 49.0 (T1A) 49.0 (T2A) 13.4 (T3A) 13.4 (T4A)	–	These tests were conducted in hard and soft water at varied temperatures. Generally, this chemical was more toxic in soft water. At temperatures up to 90 F, zinc sulfate was less toxic than at 51 F for *P. heterostropha.*	Wurtz (1962)
Zinc sulfate	*Salmo salar*	BSA	–	(O)	a c d e f	The EC_{50} or the effective concentration that produced an avoidance response in 50% of the fish was 0.092 x the ILL (incipient lethal level), or 0.092 x 580 µg/l, or 53.3 µg/l.	Sprague (1964)
Zinc (zinc sulfate)	*Salmo salar*	BCF	–	0.6 (O)	a c d e f	The experiments were carried out in soft water. Values are reported as micrograms of metal and toxicity as LT_{50}. In solutions containing copper and zinc, fish died twice as fast as would occur if the 2 metals were simply additive in their lethal action.	Sprague (1964)
Zinc sulfate (as Zn)	*Salmo gairdnerii*	BSA	–	3.86 (T2A)	a c d f	A mathematical equation was derived to explain the combined toxicities of this salt and ammonium chloride.	Herbert and Shurben (1964)
Zinc sulfate	Periphyton	FL	Newtown, Ohio	1.1-6.5 (O)	a c d f	Fungi and slime-forming bacteria grew abundantly in the high Zn concentrations, apparently due to nutrient release from decaying periphyton.	Williams and Mount (1965)
Zinc sulphate	*Brachydanio rerio*	BSA	–	(O)	a c e f	Survival time for adult fish (aged 40 days) in 168 hours was 10 ppm. The chemical was more toxic to newly hatched fish.	Skidmore (1965)
Zinc sulfate	*Pimephales promelas* *Lepomis macrochirus* *Carassius auratus* *Lebistes reticulatus*	BSA	–	(S) 0.96 (T4A) (H) 33.4 (T4A) (S) 5.46 (T4A) (H) 40.9 (T4A) (S) 6.44 (T4A) (H) 1.27 (T4A)	c d e f	(S) Soft water. (H) Hard water. Values are expressed as mg/l of metal.	Pickering and Henderson (1965)
Zinc sulfate	*Brachydanio rerio* (embryos)	BSCH	–	20 (K 15 hr)	a c e	Embryos with the outer membranes removed survived longer than natural embryos – the action of zinc sulfate on membranes is unknown. Additional data are presented.	Skidmore (1966)
Zinc sulfate	*Brachydanio rerio*	BSA	–	20 (K1)	a c d e	Data are given for several concentrations of zinc. The authors also measured oxygen uptake of the fish plotting this value against the dry weight of the fish. Toxicity of zinc to fish of different ages was also measured. An equation was derived to express toxicity of zinc to these fish.	Skidmore (1967)
Zinc sulfate (as Zn)	*Salmo salar* *S. trutta* *S. gairdnerii* *S. trutta* *S. gairdnerii*	BSCH	–	0.1 (K) (O) (O) (O) (O)	c f	The reported figure is a reported lethal concentrate as found in polluted lakes and streams in Norway. Apparently organic matter has a masking effect that reduces toxicity. Rainbow trout and Atlantic salmon reacted similarly to the chemical. Brown trout was only slightly more tolerant. The value given is for a 21-day median survival period. 50% of brown trout eggs survived to hatch in 0.3 ppm Zn. Eggs of rainbow trout behaved similarly.	Grande (1967)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Zinc sulfate	*Salmo gairdnerii*	BSA	–	4.6 (T4A)	c e	Data given as LC_{50} which was taken as equivalent to TL_m. Additional data for other exposure periods are presented.	Ball (1967)
	Perca fluviatilis			16.0 (T5A)			
	Rutilus rutilus			17.3 (T5A)			
	Gobio gobio			8.4 (T7A)			
	Abramis brama			14.3 (T5A)			
Zinc sulphate (hydrated)	*Salmo gairdnerii*	BCFA	–	3.8-5.5 (K5)			
	Perca fluviatilis			14.8-17.3 (K5)	a c e	Data confirmed that experiments of short duration are not necessarily reliable for ranking the ultimate sensitivities of several species of fish to a given poison.	Ball (1967)
	Rutilus rutilus			15.4-19.4 (K5)			
	Gobio gobio			9-15 (K5)			
	Abramis brama			12.5-16.3 (K5)			
Zinc sulfate	Tubificid worms	BSA	–	46.0 (T1A)	a c	Knop's solution was used. TL_m levels for various pHs were determined for the tubificids and were found to be 5.8 to 9.7. Zinc sulfate was more toxic at pH extremes of 6.5 and 8.5 than at 7.5.	Whitley (1968)
Zinc sulfate plus copper sulfate (various ratios)	*Salmo gairdnerii*	BSA	–	–	a e p	Both hard and soft water were used. Median period of survival in hard water was 3 days – 3.5 ppm Zn, and 1.1 ppm Cu; in soft water 7 days, 0.56 ppm Zn and 0.044 ppm Cu.	Lloyd (1961)
Zinc sulfate plus alkylbenzene sulfonate	*Salmo gairdnerii*	BCFCH & A	–	0.3* (T4A) *ABS + 0.8 ppm Zn	a b c d e f	For a concentration of 0.45 ppm of alkyl benzene sulfonate alone, the median tolerance limit was recorded in 4 days. The zinc concentration was 0.08 ppm in the combined zinc-detergent solution. The ABS appeared to block development of resistance to Zn in the trout in chronic studies.	Brown, et al (1968)
Zirconium oxychloride	*Pimephales promelas* *Lepomis macrochirus*	BSA	–	(H) 240 (T4A) (S) 18 (T4A) (H) 270 (T4A) (S) 15 (T4A)	a c d f	Both hard (H) and soft (S) water were used.	Tarzwell and Henderson (1960)
Zirconium sulfate	*Pimephales promelas*	BSA	–	(H) 145 (T4A) (S) 14 (T4A)	a c d f	Comment same as above.	Tarzwell and Henderson (1960)

APPENDIX B

EXTRACTED DATA FROM ORIGINAL PAPERS – COMMERCIAL CHEMICAL PRODUCTS

Note: Names of chemicals and organisms are as given by the various authors. Readers should search for alternate, common, and/or scientific names of both chemical and aquatic species; and refer to report section on Extracted Data for further discussion of this appendix.

Footnotes for Appendices A and B:

(1) Letters represent:
    B = bioassay, used in combination with S = static, CF = continuous flow, A = acute, and CH = chronic.
    L = laboratory bioassay.
    BOD = biochemical oxygen demand.
    F = field study, used in combination with R = river, stream, creek, etc., L = lake or pond, M = marine, E = estuarine, and O = other (port facility, flooded area, etc.).

(2) Field location is indicated by abbreviation of the state or country.

(3) The number indicates ppm (mg/l), unless otherwise indicated by appropriate designations or (O). The letters within parentheses following indicate T = TL_m, K = kill, SB = sublethal effects, NTE = no toxic effect, or O = other. The number following these indicates the time in days at which observations were made. EC_{50}, LC_{50}, and similar designations for 50 percent lethality were all considered as TL_m and designated as such. The numbers within parentheses following these designations indicate the time in days when the effect was observed.

(4) The following indicate (when underlined the variable was controlled):
    a = water temperature
    b = ambient air temperature
    c = pH
    d = alkalinity (total, phenolphthalein or caustic)
    e = dissolved oxygen
    f = hardness (total, carbonate, Mg, or CaO)
    g = turbidity
    h = oxidation-reduction potential
    i = chloride as Cl
    j = BOD, 5 day; (J) = BOD, short-term
    k = COD
    l = nitrogen (as NO_2 or NO_3)
    m = ammonia nitrogen as NH_3
    n = phosphate (total, ortho-, or poly)
    o = solids (total, fixed, volatile, or suspended)
    p = CO_2

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
2389 (10%)	*Chlorella pyrenoidosa*	L	–	100 (AC 1/2 hr)	–	Describes a bioassay method to differentiate between an algicide (AC) and an algistat (AS). The treated culture was subcultured as time progressed. Allen's medium was used.	Fitzgerald and Faust (1963)
Abate	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	–	4.0 (O)	a	Stones heavily populated with larvae were placed in troughs of running water containing the toxicant. When the larvae became detached from the rocks and floated away, they were assumed to have undergone lethal intoxication. The larvae were exposed to the toxicant for 5 minutes, then in clean water for 24 hours. At that time the number detached amounted to 56 percent.	Jamnback and Frempong-Boadu (1966)
Abate (Am.Cy.52, 160)	*Micropterus salmoides*	BSA	–	200+ (L1A)	a	Abate was toxic to fish at a dosage rate necessary to control the larvae of the chironomid midge.	Von Windeguth and Patterson (1966)
	Lepomis macrochirus			200+ (L1A)			
	Gambusia affinis			200+ (L1A)			
	Lebistes reticulatus			200+ (L1A)			
	Paleomonetes paludosus			1.0 (L1A)			
	Hyalella azteca			0.65 (L1A)			
	Plankton (*Euglena, Coleps*)			50.0 (K2)			
	Rotifers			50.0 (K2)			
Abate	*Callinectes sapidus*	BCFCH	–	0.01 (K)	a	Little or no information was given about test procedures and further results.	Butler and Johnson (1967)
Abate	*Micropterus salmoides*	BSA	–	5.0 (T 1 hr) 5.0 (K 2 hr)	a e	Experiments were carried out in plastic tubs lined with saran plastic. Fish weights averaged 217 grams.	Mulla, et al (1967)
Abate	*Pteronarcys californica* (naiads)	BSA	–	0.01 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Alkyl benzene sulphonate (ABS)	*Cladophora glomerata*	BSA	–	10 (K21A)	–	Within the range of reduction of ABS detergent concentration which has been achieved by the Luton experiment there was very little biological effect on the river.	Hynes and Roberts (1962)
	Eurhynchium rusciforme			10 (K21A)			
	Ranunculus pseudofluitans			2.5 (K14)			
	Potamogeton pectinatus			2-3 (SB14)			
	P. densus			2.5 (SB14)			
Sodium alkylaryl sulfonate	Rainbow trout (fry)	BSA	–	3.0-5.0 (T1A)	a c d e	The 24-hr TL_m was very near the highest concentration that was nonlethal in 6 hr. Additional data are discussed.	Vivier and Nisbet (1965)

Sodium alkyl benzene sulfonate	*Lepomis macrochirus* *L. gibbosus*	BSA and CFCH	–	17.4 (T4A) 17.4 (T4CF) 21.9 (T4A)	a c d e	Both hard and soft water were used. Data from both were similar. TL_m for 24 and 48 hr are given. Gill damage occurred at 5-6 ppm after 3 months of exposure. Data on cruising speed and active oxygen consumption are also presented in addition to erythrocyte count and histological examination of gills. Similar gill damage for *L. macrochirus* occurred in acute and chronic studies.	Cairns and Scheier (1963)
ABS	*Lepomis macrochirus*	BCF	–	19.7 (T1A) 18.1 (T4A) 17.3 (T30A)	a c d e f q	Toxicities are recorded as an average for 3 tests. Test fish exhibited some degree of acclimation to the chemical after exposure to sublethal concentrations.	Lemke and Mount (1963)
Alkyl benzene sulfonate (25 percent)	Hydropsychidae	BCFACR	–	32 (60% K)	a c d e	Concentration, time and percent survival are given. Considerable additional data are also presented.	Surber and Thatcher (1963)
	Stenonema sp			16 (K)			
	S. ares			16 (K)			
	S. heterotarsale			16 (K)			
	Isonychia bicolor			4.0 (K)			
	Orconectes rusticus			32 (K)			
	Goniobasis sp			32 (K)			
ABS	*Lepomis gibbosus*	BSCHA	–	12 (O)	a	Fish were exposed to the ABS solution for two weeks, and subsequently to a sublethal concentration of $ZnCl_2$ (2.4 ppm). Limited tests indicated that exposure to ABS in excess of 5.6 ppm caused marked gill damage but produced no gross changes in zinc tolerance. Other fish were exposed to ABS as above, then in dilution water alone, and the temperature was raised to 35° for 96 hours. Exposure to ABS apparently caused no changes in the tolerance of the fish to the higher temperature.	Cairns and Scheier (1964)
Alkyl benzene sulfonate (54.8%)	*Nitzchia linearis*	BSA	–	(S) 10 (T5)	a c e	Effects in hard (H) and soft (S) waters were compared. Two compositions of ABS were used. TL_m is given in ppm of ABS composition.	Cairns, et al (1964)
	Navicula seminulum			(S) 5.6 (T5) (H) 39.4 (T5)			
	Physa heterostropha			(S) 34.2 (T5) (H) 35.8 (T5)			
	Lepomis macrochirus and *Lepomis gibbosus*			5.6 - 18.0 (survived, but extensive gill damage occurred)			
Sodium alkyl benzene sulfonate	*Ictalurus natalis*	BSCH	–	0.5 (SB1CH)	a c d f	At 0.5 ppm, bullhead chemoreceptor damage occurred. Detergent concentration was monitored by the methylene-blue technique.	Bennett (1962)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
ABS	*Brachydanio rerio* (adults) (eggs) *Lepomis macrochirus*	BSA	–	42.0 (T2A) 75.0 (T2A) 17.4 (T2A)	a c d e f	The test dilutions were made up from distilled water and ACS grade chemicals. Temperature was held at 24 C and the solution was aerated to maintain a dissolved oxygen content of 5-9 ppm.	Cairns, et al (1965)
ABS (54.8% active)	*Lepomis gibbosus*	BSCH	–	18 (O)	a c d e i	Chloride content of the water was adjusted to 60 ppm – and the fish were exposed to the test solution for 21 days. At this time, the chloride content was raised to 6500 ppm, and the test was continued another 21 days. ABS generally damaged the gill structure. Since salt exchange as well as oxygen exchange takes place here, it would not be surprising that gill damage would correlate with chloride content of the blood. However, there was little difference in the blood chloride in control and experimental animals.	Cairns and Scheier (1966)
Alkyl benzene sulfonate	*Vaucheria* *Cladophora*	BSA	–	(O)	a f i l n	Experiments were conducted in five 1-gal. containers. Algal communities were subsampled and the samples were placed in 60-ml bottles at 4 time periods: 12 hr, 24 hr, 48 hr, and 96 hr. Results showed that ABS has a negative effect on C^{14} uptake for both algae communities, the communities appear to partly recover their ability to assimilate C^{14} at extended exposures to high concentrations, and a slight stimulation of C^{14} uptake appears to occur at abbreviated exposures to low concentrations.	Hicks and Neuhold (1966)
ABS	*Chlorella pyrenoidosa*	L	–	0-20 mg/l increased growth rate	a c e p	Growth rates of the *Chlorella* were followed when supplied synthetic detergents as the phosphorus source. Sodium triphosphate was responsible for increased growth.	Maloney (1966)
ABS	*Pimephales promelas* (eggs)	BCF	–	6.4 (T9)	a c d e f	Mortality range is given for exposure (days 1-9) with various concentrations and controls. Additional data are presented.	Pickering (1966)
ABS (54.8%)	*Jordanella floridae*	BSCH	–	10 to 65 (NTE)	–	Aquaria were prepared containing 0, 10, 28, 42, 56, 65 ppm of ABS. The major effect found was on the feeding habits of the fish. Apparently the chemical made worms in the aquaria unpalatable. Time required for the consumption of the worms varied with the concentration of the chemical.	Foster, et al (1966)
ABS	*Lepomis gibbosus*	BSA	–	(O)	a e	Gill damage in pumpkinseed sunfish resulting from 24-hr exposure to 18 ppm of this chemical was not reversible, even after the test fish were removed to fresh dilution water for an eight-week period.	Scheier and Cairns (1967)
ABS	*Notropis antherinoides*	BCFA	–	7.4 (T4A)	a c d e f	Differences in sensitivity to ABS between closely related species was studied. Since bluntnose and fathead minnows are closely related phylogenetically and ecologically, one might expect them to be very similar in their response to a given toxicant. However, from the data in this report, this is not necessarily true since the two species were significantly different in ABS sensitivity. The differences between several species of *Notropis* also illustrate this.	Thatcher (1966)
	Pimephales notatus	BCFA	–	7.7 (T4A)			
	Lepomis macrochirus	BCFA	–	8.2 (T4A)			

	Campostoma anomalum	BCFA	—	8.9 (T4A)			
	Notropis stramineus	BCFA	—	9.0 (T4A)			
	Ericymba buccata	BCFA	—	9.2 (T4A)			
	Notropis ardens	BCFA	—	9.5 (T4A)			
	Pimephales promelas	BCFA	—	11.3 (T4A)			
	Notropis cornutus	BCFA	—	17.0 (T4A)			
	Cyprinus carpio	BCFA	—	18.0 (T4A)			
	Ictalurus melas	BCFA	—	22.0 (T4A)			
Alkyl benzene sulfonate	*Lepomis macrochirus*	BSA	—	8.2 (T4A)	a c d e	In all of these tests, the LAS stock powder contained 60.8% LAS. The values reported were calculated on a basis of pure LAS.	Thatcher and Santner (1967)
	Pimephalus promelas			11.3 (T4A)			
	Ictalurus melas			22.0 (T4A)			
	Notropis atherinoides			7.4 (T4A)			
	Notropis cornutus			17.0 (T4A)			
ABS (54.8%)	*Nitzschia linearis*	BSA	—	10.0 (T5A)	a e	The purpose of this experiment was to determine whether there was a constant relationship between the responses of these organisms. From the data presented, there was no apparent relationship of this type. Therefore the authors advise that bioassays on at least 3 components of the food web be made in any situation.	Patrick, et al (1968)
	Physa heterostropha			34.2 (T4A)			
	Lepomis macrochirus			17.44 (T4A)			
Alkyl benzene sulfonate plus zinc sulfate	*Salmo gairdnerii*	BCFCH & A	—	0.3* (T4A) *ABS + 0.8 ppm Zn	a b c d e f	For a concentration of 0.45 ppm of alkyl benzene sulfonate alone, the median tolerance limit was recorded in 4 days. The zinc concentration was 0.08 ppm in the combined zinc-detergent solution. The ABS appeared to block development of resistance to Zn in the trout in chronic studies.	Brown, et al (1968)
AC-5727 (15 percent EC)	*Gambusia affinis*	FL	Ponds — Bakersfield, Calif.	(O)	a c	At 0.2 lb/acre, 2 percent mortality occurred in 24 hours. At 0.8 lb/acre, 20 percent mortality occurred in 24 hours. The experiments were conducted in cages placed in the ponds.	Mulla and Isaak (1961)
AC-5727	*Salmo gairdnerii* (one wk old sac fry)	BSA	—	0.5 (K 0%) 5.0 (K 0%)	a e	Results are averages of triplicate tests. Toxicity is reported as percent mortality (K %).	Lewallen and Wilder (1962)
	(one mo old feeding fry)			0.5 (K 0%) 5.0 (K 0%)			

Chemical	Organism	Bioassay or Field Study$^{(1)}$	Field Location$^{(2)}$	Toxicity, Active Ingredient, ppm$^{(3)}$	Experimental Variables Controlled or Noted$^{(4)}$	Comments	Reference (Year)
American Cyanamid 12009 (tech)	*Pimephales promelas*	BSA	–	0.32 (T4A)	a c d e f	The toxicity of this substance was not influenced by the quality of the water (pH, hardness, alkalinity).	Pickering and Henderson (1966)
	Lepomis macrochirus			0.075 (T4A)			
	Lebistes reticulatus			0.010 (T4A)			
American Cyanamid 43,913	*Leiostomus xanthurus* (juvenile)	BSA	–	(O)	a	Water temperature was 13 C. 20% mortality at 1.0 ppm occurred.	Butler (1965)
	Oyster	BCF		0.20 (O)		The value reported is a 96-hr EC_{50} (decreased shell growth).	
AC-43913	*Australorbis glabratus*	BSA and FL	Puerto Rico	(O)	c	Seven of the tested compounds failed to meet acceptability criteria – that is, complete kill after 6-hr exposure to 10 ppm. They were not used in field tests. Field tests showed WL 8008 to be highly effective. All others failed.	Seiffer and Schoof (1967)
AC-47031 (EC4)	*Gambusia affinis*	FL	Cal.	0.5 (K1)	–	Toxicity value is in lb/acre.	Mulla (1966)
AC-47921 (EC4)	*Gambusia affinis*	FL	Cal.	0.4 (O)	–	At a concentration of 0.4 lb/acre, 96% mortality of the fish occurred in 24 hours. No mortality in tadpoles of *R. catesbeiana* occurred during an exposure period of one week. Toxicity value is in lb/acre.	Mulla (1966)
	Rana catesbeiana			(O)			
AC-47921 (EC4)	*Gambusia affinis*	FL	Cal.	0.1 (K1)	–	Toxicity value is in lb/acre.	Mulla (1966)
Amer. Cyanamid 52,160	Oyster	BCF	–	0.042 (O)	a	The value reported is a 96-hr EC_{50} (decreased shell growth).	Butler (1965)
	Oyster	BCF		(O)		Exposure to a concentration of 1 ppm caused a 35.0% decrease in shell growth.	
	Leiostomus xanthurus (juvenile)	BSA		(O)		Water temperature was 13 C. Fish showed irritation at 1.0 ppm.	
Amer. Cyan. 52160	Rainbow trout	–	–	1.0 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
ACP-M-569	*Onchorynchus tshawytscha*	BSA	–	185 (T1A) 155 (T2A)	a c d e	Concentrations were based on percent active ingredient.	Bond, et al (1960)
ACP (a-chloroacetophenone)	Green sunfish	BSA and FL	Okla.	1.1 (T1A) 1.05 (T2A)	a e p	The main purpose of this experiment was to determine the repellent characteristics of certain chemicals. Tests were conducted at 22 C to 23 C. BSA experiments were made in a wooden trough.	Summerfelt and Lewis (1967)
Acriflavin	*Microcystis aeruginosa*	L	–	1.0 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1×10^6 to 2×10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)

Acriflavine	*Ictalurus punctatus* (fry)	BSA	–	5.0 (SB3)	a c d e f p	At least 90 percent of the fry survived for a period of 72 hours at the concentration listed.	Jones (1965)
	Lepomis macrochirus (fry)			5.0 (SB3)			
Acriflavine	*Salmo gairdnerii*	BSA	–	19.9 (T2A)	a f	Variance and the 95-percent confidence interval (C.I.) were also determined.	Willford (1966)
	Salmo trutta			27.0 (T2A)			
	Salvelinus fontinalis			14.8 (T2A)			
	Salvelinus namaycush			28.0 (T2A)			
	Ictalurus punctatus			33.2 (T2A)			
	Lepomis macrochirus			13.5 (T2A)			
Acrylaldehyde (acrolein)		BSA	–		a	Experiments were conducted in standing water. Results were rated on a scale of 0 to 10, 0 standing for no toxic effect and 10 signifying a complete kill. Evaluation was based on visual observation of the plant response at weekly intervals for 4 weeks.	Frank, et al (1961)
Acti-dione	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – PT (7) Ma – NT So – T Cv – PT (7) Gp – T Np – T	Palmer and Maloney (1955)
Aerosporin-Polymyxin B (sulfate)	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Comment same as above except that: Cl – T Ma – T So – T (14) Cv – T Gp – T Np – T	Palmer and Maloney (1955)
Aldrin (hexachloro-hexahydro-dimethanonaphthalene, 48 percent)	Lymnaeid snails	BSA	–	(O)	–	Each test container (500-ml beaker) was filled with ditch water. 100% mortality occurred at 1:100,000 and greater.	Batte, et al (1951)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Aldrin	Fathead minnow Bluegill Goldfish Guppy	BSA	–	0.033 (T4A) 0.013 (T4A) 0.028 (T4A) 0.033 (T4A)	a	It was the authors opinion that pH, alkalinity and hardness, within the usual range in natural waters, had little effect on the toxic effect of the compounds studied. The values given are from Henderson, Pickering, and Tarzwell, "The Relative Toxicity of Ten Chlorinated Hydrocarbon Insecticides to Four Species of Fish". It is interesting that the different tables from the above book (as reported in this paper) report widely different values for the same compounds.	Tarzwell (1959)
Aldrin	Fathead minnow	BSA	–	0.028 (T4A)	a	Comments same as above except that the experiment was performed in hard water.	
Aldrin	*Pimephales promelas* *Lepomis macrochirus* *Carassius auratus* *Lebistes reticulatus*	BSA	–	0.03 (T4A) 0.01 (T4A) 0.03 (T4A) 0.03 (T4A)	a d e f	Concentrations were based on percent active ingredient.	Henderson, et al (1959)
Aldrin (88.4%)	*Pimephales promelas* *Lepomis macrochirus* *Carassius auratus* *Lebistes reticulatus*	BSA	–	0.032 (T4A) 0.015 (T4A) 0.032 (T4A) 0.037 (T4A)	a b e c d f	Dilution water was usually soft although some studies were conducted with hard water.	Henderson, et al (1959)
Aldrin	*Pimephales promelas* *Lepomis macrochirus*	BSA	–	0.033 (T4A) 0.013 (T4A)	a	Bioassay investigations of the new insecticides indicate that in general the organic phosphorus compounds are not as toxic to fish as are the chlorinated hydrocarbons. The toxicity of most of these materials was not significantly influenced by water quality. Therefore it is to be expected that the toxicity of these materials will not differ significantly in different streams.	Tarzwell (1959)
Aldrin (dust)	*Tilapia melanopleura*	FLCH	Tanganyika	1.0 lb (3.3% K) 5.0 lb (3.3% K - 3 wks) 10.0 lb (60.0% K - 3 wks)	–	Trial periods were for 20 weeks. Sublethal effects such as impaired breeding, retarded growth, or altered taste were not detected. Dosages are given as lb/acre of surface water.	Webbe and Shute (1959)
Aldrin	*Daphnia magna*	BSA	–	0.0292 (O)	a	The indicated concentration immobilized *Daphnia* in 50 hours.	Anderson (1960)
Aldrin	*Oncorhynchus kisutch* *Oncorhynchus tshawytscha* *Salmo gairdnerii* *Gasterosteus aculeatus*	BSA	–	45.9 (T4A) 7.5 (T4A) 17.7 (T4A) 39.8 (T4A)	a c d e	Chemical dissolved in acetone. TL_m expressed in ppb.	Katz (1961)

Aldrin	*Gammarus lacustris lacustris*	BSA	–	(O)	a e p	The mortality might have been partially due to the susceptibility of the organism to higher temperatures, toxicity from extended exposure to copper electrodes (used to shock the organism to determine death), or the increase of CO_2. Results were expressed as LT_{50}; for example, at 0.5 ppm, 50 percent of the shrimp were killed in 200 (±35) min.	McDonald (1962)
Aldrin (EC 2)	*Gambusia affinis* *Rana catesbeiana* (tadpoles)	FL	Cal.	0.5 (O)	a c	Mixed populations of the indicated test species contained in cages were exposed to various insecticidal chemicals applied as dilute sprays to ponds 1/16 acre in size. The indicated toxicant concentration is in lb/acre, and resulted in a 90 percent mortality for the fish, and a 80 percent mortality for the tadpoles in 24 hours.	Mulla, et al (1963)
Aldrin	*Lepomis macrochirus* *Salmo gairdneri*	BSA	–	10 (T1A) 6 (T2A)	a	The experiment was conducted at 65 F.	Cope (1963)
Aldrin	Aquatic insects: Ephemeroptera Trichoptera Chironomidae Fish: *Moxostoma erythrurum* *Hypentelium nigricans* *Catostomus commersoni* *Pimephales notatus* *Notropis chrysocephalus* *Semotilus atromaculatus* *Campostoma anomalum* *Ericymba buccata* *Etheostoma zonale* *Hybopsis biguttata* *Percina maculata* *Notropis spilopterus* *N. stramineus* *N. volucellus* *Etheostoma caeruleum* *Notropis umbratilis*	FR	Ill.	(O)	–	Dosage application rate was 2 lb aldrin/acre. After initial application a great number of fish and insects of indicated species were killed. A collection, made 7 months later, showed this stream contained a diversity of insect species and sizes of fish.	Moye and Luckmann (1964)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Aldrin	Bluegill	BSA	–	0.013 (T4A)	a	Assays were conducted in soft water at 25 C. Decrease in brain cholinesterase was measured in fish exposed to the toxicant.	Weiss (1964)
Aldrin	*Notemigonus crysoleucas* *Lepomis macrochirus* *L. cyanellus*	BSA	–	(B) 0.080 (T 1.5) (A) 4.750 (T 1.5) (B) 0.038 (T 1.5) (A) 3.0 (T 1.5) (B) 0.062 (T 1.5) (A) 3.25 (T 1.5)	a c f	Chemical was dissolved in acetone. Final concentration of acetone was <2 ml/l. Data shows TL_m ppb for insecticide-resistant (A) and insecticide non-resistant (B) strains of the test fish.	Ferguson, et al (1964)
Aldrin	*Gammarus lacustris*	BSA	–	38.5 (T4A)	a e	Emulsible concentrates were prepared from technical grade insecticides with acetone as the solvent. Symptoms prior to death were observed and recorded on graphs.	Nebeker and Gaufin (1964)
Aldrin	*Gambusia affinis affinis*	BSA	–	0.05 to 2.1 (O)	a	The lower value is for fish that had never been exposed to the toxicant, and the higher value was obtained with fish that had been exposed to a sublethal dose in the past. Apparently such an exposure produces a resistance that can be retained when they are exposed later.	Boyd and Ferguson (1964)
Aldrin	*Paleomonetes kadiakensis*	BSA	–	(N) 85 (T1½A) (TB) 185 (T1½A)	a c i	Test organisms were collected from 2 locations, Twin Bayou (TB), Sunflower Co., Miss. (Agricultural area) and Noxubee National Wildlife Refuge (N), Noxubee Co., Miss. (non-agricultural area) and evaluated in laboratory bioassays. The Twin Bayou shrimp were more resistant.	Ferguson, et al (1965)
Aldrin	*Acroneuria pacifica*	BSA	–	0.143 (T4A)	a c	Additional TL_m data are given.	Gaufin, et al (1965)
	Ephemerella grandis			0.009 (T4A)			
	Gammarus lacustris			38.5 (T4A)			
	Pteronarcys californica			0.18 (T4A)			
Aldrin	*Procambarus clarkii*	BSA	–		a c d o	The pesticides studied in this report are widely used in rice culture in Louisiana and are toxic to crawfish.	Hendrick and Everett (1965)
	(juvenile)			0.038 (T5A)			
	(adult)			0.60 (T5A)			
Aldrin	*Gambusia affinis*	BSA	–	0.02-0.06 (T3A)	a c d e	Test fish were collected from 8 different locations of the Mississippi River. The 3-day TL_m values were made to determine if a resistance gradient existed. The data indicated that there was none.	Ferguson, et al (1965)
	Ictalurus melas			0.013-0.185 (T3A)			
Aldrin (tech)	Rainbow trout	BSA	–	0.031 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
	Bluegill			0.0052 (T4A)			

Aldrin	*Pteronarcys californica* *Acroneuria pacifica* *Ephemerella grandis* *Daphnia magna* *Gammarus lacustris*	BSA	–	0.18 (T4A) 0.1 (T4A) 0.009 (T4A) 0.03 (T 50 hr A) 38.5 (T4A)	a	Unspecified chemical characteristics of assay water were determined by standard methods. General comments were made concerning "standardized" conditions, use of "soft" water, and use of emulsifying agents. Additional data are presented.	Gaufin, et al (1965)
Aldrin (tech, 93 percent active in acetone)	*Pteronarcys californica* (naiad) *Acroneuria pacifica* (naiad)	BSA	–	0.180 (T4A) 0.143 (T4A)	c d e f	*A. pacifica* was much more sensitive to chlorinated hydrocarbons and to organic phosphate insecticides than *P. californica*.	Jensen and Gaufin (1964)
Aldrin	Bluegill	BSA	–	9.7 (T4A) 7.7 (T4A) 6.2 (T4A) 5.6 (T4A)	a	These experiments were performed to demonstrate that at increased temperatures the toxic effect of most chemicals is increased. For the toxicant concentrations listed, the temperatures were respectively, 45, 55, 65, 75, and 85 F. Data on the effect of time as well as temperature was also reported. The experimental animals all were approximately one gram in weight.	Cope (1965)
Aldrin	*Acroneuria pacifica* *Pteronarcys californica*	BSA & CFCH	–	0.143 (T4A) 0.022 (T30CH) 0.180 (T4A) 0.0025 (T30CH)	a c d e	Additional data are presented.	Jensen and Gaufin (1966)
Aldrin	*Procambarus clarkii*	FO	Crowley, La.	(O)	c d e p	Experiments were conducted in a flooded rice field. Area was divided into 4 blocks with a fence, restricting crawfish to desired areas. The rearing of crawfish in rice fields is of considerable commercial importance in Louisiana. No untoward effect on the crawfish occurred. Aldrin was used on the rice seed at the rate of 0.25 lb/100 lb seed. Even with the addition of carbonyl solution 0.8 lb/acre showed no more effect.	Hendrick, et al (1966)
Aldrin	*Daphnia magna*	BSA	–	0.030 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
Aldrin	*Notropis umbratilis* *N. umbratilis* (2 in.) *N. cornutus*	BSA	–	0.02-0.08 (T4A) 0.4 (T4A) 0.02-0.08 (T4A)	a c d e	Aerated pond water was used as diluent. Both aquarium and a "boat" were used as test vessels. Other experiments with oxygen concentration variations are reported.	Proffitt (1966)

(continued)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
	N. blennius (2 in.)			0.6 (T6A)			
	Spotfins						
	(2 in.)			0.6 (T6A)			
	(3 in.)			0.6 (T8A)			
	Lepomis macrochirus						
	(<1-1/2 in.)			0.2 (T2A)			
	(1-1/2 in.)			0.4 (T4A)			
	(2 in.)			0.6 (T6A)			
	L. cyanellus						
	(1-1/2 in.)			0.4 (T4A)			
	(3 in.)			0.6 (T6A)			
	Microptera salmoides (2-1/2 in.)			0.4 (T4A)			
	Fundalus notatus (1-1/2 in.)			0.6 (T8A)			
	Etheostoma flabellare (2 in.)			0.6 (T8A)			
	Noturus miurus			0.6 (T8A)			
	Etheostoma nigrum (2 in.)			0.8 (T10A)			
	E. caeruleum (2 in.)			0.8 (T10A)			
	E. blennioides (2-1/2 in.)			0.8 (T10A)			
	Campostoma anomalum (5 in.)			0.8 (NTE)			
	Hypentelium nigricans (5-1/2 in.)			0.8 (NTE)			
	Ericymba buccata			0.21 (K2A)			
	Hypognathus nuchalis			0.25 (K2A)			
Aldrin	*Simocephalus serrulatus*	BSA	–	0.023 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 48 hr. Data cited are for 60 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
	Daphnia pulex			0.028 (SB)			
Aldrin	Catfish Buffalo fish Perch Bluegill	L	–	(O)	–	The chemical was found from 0.02 to 0.21 ppm as residues in catfish, and 0.01 to 0.04 in buffalo fish – after a soil treatment nearby of 5 lb/acre.	Sparr, et al (1966)

Aldrin	Oyster	BCF	–	0.001 (SB4) 1.0 (SB4)	a	Seawater was employed in this experiment.	Butler (1966)
Aldrin	*Daphnia carinata*	BSA	–	0.0040 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
Aldrin	*Mya arenaria* *Crassostrea virginica* *Corbicula manillensis* *Mercenaria mercenaria* *Rangia cuneata*	BCFCH	–	(O)	–	Results are recorded as a range of uptake of the chemical by 5 species of aquatic mollusks. An uptake or concentration of 350-4500X resulted.	Butler (1967)
Aldrin	Oyster	FE	Galveston Bay, Texas	(O)	–	Oysters from the area were found to contain from none to 0.03 ppm.	Casper (1967)
Aldrin	*Lampsilis siliquoidea* *L. ventricosa* *Anodonta grandis*	F	Red Cedar River, Mich.	(O)	–	The mussels listed were analyzed for the toxicant and its metabolites. Mussels may be used as detectors for this toxicant, because they tend to concentrate the chemical in much higher concentrations than it is ever found in the water. The amount of chemical applied as a spray was not specified.	Bedford (1968)
^{14}C-Aldrin	*Carassius auratus (Linnaeus)*	BSA	–	0.05 (SB)	a	Immediately after 8-hr exposure ^{14}C-Dieldrin was detected in various tissues; percentages increased with time until at 32 days they were 93.9% or more except for visceral fat; 50 and 100% of the residues were Dieldrin within 2.5-5.4 and 31.5-92.4 days, respectively; in visceral fat the corresponding times were 48.9 and 14,733 days.	Gakstatter (1968)
Aldrin	*Pteronarcys californica* (naiads)	BSA	–	0.0013 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Algeeclear	*Chlorella pyrenoidosa*	L	–	20 (AS 1)	--	Describes a bioassay method to differentiate between an algicide (AC) and an algistat (AS). The treated culture was subcultured as time progressed. Allen's medium was used.	Fitzgerald and Faust (1963)
Algibiol	*Phoxinus phoxinus*	BSA	–	25 (K2A) 20 (T1A)	a c d e	The assays were conducted in a dual aquarium with aeration. The highest dilution that was nonletal was 7.5 ppm.	Vivier and Nisbet (1965)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Algimaster	*Chlorella pyrenoidosa*	L	–	3.0 (AC<1/2)	–	Describes a bioassay method to differentiate between an algicide (AC) and an algistat (AS). The treated culture was subcultured as time progressed. Allen's medium was used.	Fitzgerald and Faust (1963)
Algimycin (MT-4)	*Chlorella pyrenoidosa*	L	–	3.0 (AC < 1/10)	–	Comment same as above.	Fitzgerald and Faust (1963)
Algimycin 200	*Chlorella pyrenoidosa*	L	–	3.0 (AC < 1/2)	–	Comment same as above.	Fitzgerald and Faust (1963)
Allethrin	*Pteronarcys* sp (nymphs)	BSA	–	0.0021 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Allethrin (tech)	Rainbow trout	BSA	–	0.019 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
Allethrin	*Simocephalus serrulatus* *Daphnia pulex*	BSA	–	0.056 (SB) 0.021 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 48 hr. Data cited are for 60 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
Allethrin	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	–	0.4 (O)	a	Stones heavily populated with larvae were placed in troughs of running water containing the toxicant. When the larvae became detached from the rocks and floated away, they were assumed to have undergone lethal intoxication. The larvae were exposed to the toxicant for 5 minutes, then in clean water for 24 hours. At that time the number detached amounted to 67 percent.	Jamnback and Frempong-Boadu (1966)
Allethrin	*Pteronarcys californica* (naiads)	BSA	–	0.0021 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Altacide 2,4-D	Spatterdock	FL	Fla.	(O)	–	At 10.0 lb/acre, 2 percent control of spatterdock was obtained.	Copeland and Woods (1959)
p-aminophenol	*Daphnia magna*	BSA	–	2 (K2A)	a	An attempt was made to correlate the biological action with the chemical reactivity of selected chemical substances. Results indicated a considerable correlation between the aquarium fish toxicity and antiautocatalytic potency of the chemicals in marked contrast to their toxicity on systemic administration.	Sollman (1949)

Amiton oxalate	*Carassius auratus* *Lepomis macrochirus*	BSCH	–	10 (O)* 10 (O)* *in response, 15 days	a c d e	Toxicity was determined by measuring acetylcholinesterase activity in the brains of fish. Concentrations are given in ppb as either response or not response in 15 or 30 days.	Weiss and Gakstatter (1964)
Amitrol-T	*Lepomis macrochirus*	BSA	–	(O)	a	No mortality in 2-in. fish was noted with concentrations of 10,000 mg/l over 100 hr at 65 F.	Cope (1963)
Ametryne	*Crassostrea virginica* *Penaeus aztecus* *Leiostomus xanthurus* Phytoplankton	BCFA & BSA	–	1.0 (NTE) 1,0 (0, 10%) 1.0 (NTE) –	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
Ametryne	*Penaeus aztecus*	L	–	(O)	a	Toxicant chemicals were evaluated in sea water at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality. No effect occurred at 1.0 ppm.	Butler (1965)
	Oyster	BCF	–	(O)	a	Exposure to a concentration of 1.0 ppm caused a 14.0% decrease in shell growth.	
	Leiostomus xanthurus (juvenile)	BSA	–	(O)	a	Water temperature was 28 C. No effect was noticed on exposure to 1.0 ppm.	
Aminotriazol	*Panicum hemitomum*	FL	Fla.	(O)	–	At 10 lb/acre, 5-7 percent control of *P. hemitomum* was obtained.	Copeland and Woods (1959)
Aminotriazole	*Oncorhynchus kisutch* *Micropterus salmoides*	BSA and CF	–	325 (T1A) 325 (T2A) (O)	a c d e	Concentrations were based on percent active ingredient. In the constant-flow (CF) apparatus, 1000-ppm aminotriazole killed all test fish in 6 days.	Bond, et al (1960)
Aminotriazole	Salmon	BSA	–	325 (T2A)	–	Data are given as LC_{50}.	Bohmont (1967)
Amitrole	*Daphnia magna*	BSA	–	23 (15.3-44.4) (O)	a c d i q	Toxicity, in terms of median immobilization concentration (IC_{50}), is presented.	Crosby and Tucker (1966)
Amitrole	*Lepomis macrochirus* (eggs) *L. cyanellus* (eggs) *Micropterus dolomieui* (eggs)	L	–	50 (NTE) 50 (NTE) –	–	Fertilized fish eggs of indicated species were placed in 1 liter of test solution and allowed to hatch. Toxicity data are presented as concentration in ppm/number of days survival. Maximum length of test was 8 days. No food was added. Small bluegill were tested to find the highest concentration of chemical which did not cause death in 12 days (S).	Hiltibran (1967)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
	Erimyzon sucetta (eggs)			50 (NTE)			
	L. macrochirus (fry)			25 (S)			
Amitrole T	*Daphnia magna*	BSA	–	40 (14.3-112.0) (O)	a c d i q	Toxicity, in terms of median immobilization concentration (IC_{50}), is presented.	Crosby and Tucker (1966)
Ammate	*Althernanthera philoxeroides* *Typha latifolia*	FL	Fla.	(O)	–	At 76 and 120 lb/acre, respectively, 1 percent control of alligator weed was obtained while 80 percent control of cattail was obtained with the higher application rate.	Copeland and Woods (1959)
Ammate	Channel catfish (fingerlings)	BSA	–	259 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Amopyroquin	*Salmo gairdneri*	BSA	–	35.3 (T2A)		Variance and the 95-percent confidence interval (C.I.) were also determined.	Willford (1966)
	Salmo trutta			36 (T2A)			
	Salvelinus fontinalis			40 (T2A)			
	Salvelinus namaycush			14 (T2A)			
	Ictalurus punctatus			12.5 (T2A)			
	Lepomis macrochirus			18.5 (T2A)			
Antimycin A	*Salmo gairdneri*	BSA	–	0.25 (T18 hr)	a	The experiment was conducted at 55 F. Fish were 2-3 in. long.	Cope (1963)
Antimycin A	*Dorosoma cepedianum*	BSA	–	800 (K1A) 100 (K4A)	a d e f i l m p	Results were reported at 12 C. All fish were killed in 24 hr by 40 ppm at 22 C.	Walker, et al (1964)
	Salmo gairdneri			600 (K1A) 80 (K4A)		Results were reported at 12 C.	
	S. trutta			400 (K1A) 80 (K4A)		Results were reported at 12 C.	
	Esox leucius			800 (K1A)		Results were reported at 12 C. All fish were killed in 24 hr by 200 ppm at 17 C; by 100 ppm at 22 C.	
	Compostoma anomalum			1,000 (K1A)			
	Carassius auratus			100,000 (K1A) 2,000 (K4A)		Results were reported at 12 C. All fish were killed in 24 hr by 4,000 ppm at 22 C.	
	Notemigonus crysoleucas			2,000 (K1A) 600 (K4A)		Results were reported at 12 C. All fish were killed in 24 hr by 500 ppm at 22 C.	

	Pimephales promelas			2,000 (K1A) 400 (K4A)		Results were reported at 12 C. All fish were killed in 24 hr by 800 ppm at 22 C.	
	Catostomus commersoni			220 (K4A)		Results were reported at 12 C.	
	Ictiobus cyprinellus			400 (K4A)		Results were reported at 12 C.	
	Ictalurus melas			120,000 (K1A) 80,000 (K4A)		Results were reported at 12 C. All fish were killed in 24 hr by 40,000 ppm at 22 C.	
	I. natalis			80,000 (K1A)		Results were reported at 12 C.	
	I. punctatus			20,000 (K1A)		Results were reported at 12 C. All fish were killed in 124 hr by 6,000 ppm at 22 C.	
	Eucalia inconstans			5,000 (K1A)		Results were reported at 12 C.	
	Lepomis cyanellus			2,000 (K1A) 800 (K4A)		Results were reported at 12 C. All fish were killed in 24 hr by 800 ppm at 22 C.	
	L. gibbosus			2,000 (K1A) 200 (K4A)		Results were reported at 12 C. All fish were killed in 24 hr by 200 ppm at 22 C.	
	L. macrochirus			1,000 (K1A) 400 (K4A)		Results were reported at 12 C. All fish were killed in 24 hr by 200 ppm at 22 C.	
	L. megalotis			2,000 (K1A) 400 (K4A)		Results were reported at 12 C. All fish were killed in 24 hr by 4,000 ppm at 22 C.	
	Micropterus salmoides			6,000 (K1A) 800 (K4A)		Results were reported at 12 C.	
	Poxomis annularis			2,000 (K1A)		Results were reported at 12 C.	
	Etheostoma exile			660 (K1A)		Results were reported at 12 C.	
	Perca flavescens			660 (K1A)		Results were reported at 12 C. All fish were killed in 24 hr by 660 ppm at 22 C.	
	Stizostedion vitreum			660 (K1A)		Results were reported at 12 C.	
	Cyprinus carpio			2,000 (K1A) 600 (K4)		Results were reported at 12 C.	
Antimycin A	*Salmo gairdneri*	FL	Wisc.	600 (K1A) 80 (K4A)	a c d g	Results were recorded at 12 C. All fish were killed in 24 hr by 80 ppm at 17 C.	Walker, et al (1964)
	S. trutta			400 (K1A) 80 (K4A)		Results were recorded at 12 C. All fish were killed in 24 hr by 60 ppm at 17 C.	
Aquaherb (2,4-D ester)	*Althernanthera philoxeroides*	FL	Fla.	(O)	–	At 14.2 pounds per acre, only 1-2 percent control of alligator weed was obtained.	Copeland and Woods (1959)
Aqualin (acrolein)	*Salmo trutta*	BCFA	–	0.046 (T1CFA)	a c e	Spring water was used as dilution water. The chemical was found to be toxic to the test fish at concentrations below that recommended to control aquatic vegetation.	Burdick, et al (1964)
	Lepomis machrochirus			0.079 (T1CFA)			

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Aqualin	*Carassius auratus*	BSA	–	1.0-2.0 (K 3 hr)	a	Fiber glass tanks were used as test containers. Goldfish were acclimated to the tank habitat for 2 weeks before testing. Detoxification of the tank occurred within 43 hours when a concentration of 3.0 ppm was applied.	St. Amant, et al (1964)
Aqualin	*Carassius auratus*	FL	California	3.0 (K1) 2.0 (K 18 hr) 1.0 (K1)	a c e	The chemical was applied to Big Bear Lake at 3 ppm. Within 24 hours all fish in the area died. Fish were placed in Mentone pond in 3 live cars. An area between 2 dams separate from Big Bear Lake was tested. This area was made up of 26 acre-feet of water at a surface temperature of 72 F between the two dams. At 1.0 ppm distress of fish was evident in 1 hour and most visible fish died in 2 hours. In 1 day, all fish in live cars were dead.	St. Amant, et al (1964)
	Ictalurus nebulosus			2.0 (K 18 hr)		Fish were placed in Mentone pond in 3 live cars.	
Aqua San	*Pistia stratiotes*	FL	Fla.	(O)	–	At 32.0 lb/acre, 2 percent control of water lettuce was obtained.	Copeland and Woods (1959)
Aquasan (colloidal Ag)	*Microcystis aeruginosa*	L	–	100 (K)	a	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
Aqua San 2,4-D	*Pistia stratiotes* Spatterdock	FL	Fla.	(O)	–	At 20.0 and 25.0 lb/acre, respectively, 8 percent control of water lettuce was obtained while spatterdock was not controlled at the higher rate.	Copeland and Woods (1959)
Aquathol	*Gammarus lacustris*	BSA	–	>320 (T4A)	a e	Emulsible concentrates were prepared from technical grade insecticides with acetone as the solvent. Symptoms prior to death were observed and recorded on graphs.	Nebeker and Gaufin (1964)
Aquatic	*Richardsonius balteatus hydroflox*	BSA	–	83 (T1A) 75 (T2A) 75 (T4A)	a c d e f	Results given were in soft water. Results in hard water were as follows: 57 (T1A), 83 (T2A), and 78 (T4A).	Webb (1961)
Aramite -chloro-ethyl, -(P-tertiary-butylphenoxy) methty-ethyl sulfite, 15 percent	Lymnaeid snails	BSA	–	(O)	–	Each test container, 500-ml beaker, was filled with ditch water. Less than 100% mortality occurred in concentrations of 1:100,000.	Batte, et al (1951)
Aramite (15%)	Channel catfish (fingerlings)	BSA	–	>100 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Aramite (tech)	Rainbow trout	BSA?	—	0.320 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)

Aramite	*Simocephalus serrulatus*	BSA	–	0.180 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 48 hr. Data cited are for 60 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
	Daphnia pulex			0.160 (SB)			
Armazide	*Chlorella pyrenoidosa*	L	–	3.0 (AC 1)	–	Describes a bioassay method to differentiate between an algicide (AC) and an algistat (AS). The treated culture was subcultured as time progressed. Allen's medium was used.	Fitzgerald and Faust (1963)
ATA (3 amine-1,2,3, trizole as the active ingredient)	*Richardsonius balteatus hydroflox*	BSA	–	1330 (T1A) 1163.3 (T2A) 983.3 (T4A)	a c d e f	Results given were in soft water. Results in hard water were as follows: >3600 (T1A), >3600 (T2A), and 1370 (T4A).	Webb (1961)
Atabrine	*Microcystis aeruginosa*	L	–	100 (K)	a	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
Atabrine	Channel catfish (fingerlings)	BSA	–	0.93 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Atlas "A"	*Najas quadalupensis*	FL	Fla.	(O)		At 50.3 lb/acre, *N. quadalupensis* was not affected.	Copeland and Woods (1959)
Atlas 1901	*Pandalus montagni*	BSA	–	87.2 (T2A)	a e	Experiments were conducted in tanks holding 10 liters of seawater at 15 C. It was shown that the toxicity of this solvent emulsifier decreased with time, due to evaporation of the solvent. Atlas 1901 at a concentration of 33.3 ppm killed 95% of *Crangon crangon* larvae in 3 hr.	Portmann and Connor (1968)
	Crangon crangon			120.0 (T2A)			
	Carcinus maenas			150.0 (T2A)			
	Cardium edule			48.5 (T2A)			
Atlox 2082 A (spray emulsifier for DDT)	*Oncorhyncus kisutch*	BSA	–	20.7 (T2A)	a	The figure cited is calculated from the data. The compound is an alkyl sulfonate.	Alderdice and Worthington (1959)
Atrazine	*Micropterus salmoides* (fry)	BSA	–	5.0 (SB3)	a c d e f p	At least 90 percent of the fry survived for a period of 72 hours at the concentration listed.	Jones (1965)
	Ictalurus punctatus (fry)			10 (SB3)			
	Lepomis macrochirus (fry)			10 (SB3)			

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Atrazine	*Phoxinus phoxinus*	BSA	–	5.0 (K2A) 1.25 (K2A)	a c d e	The assays were conducted in a dual aquarium with aeration. The chemical was still toxic to minnows at 2.5 and 5.0 ppm in the presence of plants. Kill occurred between 8-15 days.	Vivier and Nisbet (1965)
Atrazine (gesaprime)	*Phoxinus phoxinus*	BSA	–	10 (K2A)	a d c e	The maximum nonlethal dose in 48 hours was 2.5 ppm.	Vivier and Nisbet (1965)
Atrazine	*Leiostomus xanthurus* (juvenile)	BSA	–	(O)	a	Water temperature was 28 C. No effect was noticed on exposure to 1.0 ppm.	Butler (1965)
	Oyster	BCF	–	(O)	a	No effect on exposure to the chemical at 1.0 ppm.	Butler (1965)
Atrazine	*Crassostrea virginica* *Penaeus aztecus*	BCFA & BSA	–	1.0 (NTE)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
	Leiostomus xanthurus Phytoplankton			1.0 (NTE)			
Atrazine (WP)	*Lepomis macrochirus* (eggs)	L	–	(O)	–	Fertilized fish eggs of indicated species were placed in 1 liter of test solution and allowed to hatch. Toxicity data are presented as concentration in ppm/number of days survival. Maximum length of test was 8 days. No food was added. Small bluegill were tested to find the highest concentration of chemical which did not cause death in 12 days (S).	Hiltibran (1967)
	Micropterus dolomieui (eggs)			10/3 (O)			
	Erimyzon sucetta (eggs)			10 (NTE)			
	L. macrochirus (fry)			5.0 (S)			
Atrazine (granular)	*Lepomis macrochirus* (eggs)	L	–	10 (NTE)	–	Comment same as above.	Hiltibran (1967)
	L. cyanellus (eggs)			10 (NTE)			
	L. macrochirus (fry)			10 (S)			

Azide	*Mayorella palestinensis* soil amoeba	BSA	–	(C)	a c	The experiments were carried out in Warburg manometers at 27 C for 4 hr as a pH of 8.0 Azide in concentrations up to 2 x 10^{-3} M were shown to have lethal effects on the organism. Results were compared with controls and expressed in percent of respiration. Compared with normal respiration, nonlethal concentrations of azide increased the respiration of the organism in glucose-containing solutions. It was concluded that the respiration of the organism depends on at least three enzyme systems, which may be distinguished by their behavior toward azide.	Reich (1955)
Bayer 29493 (Baytex)	*Procambarus simulans simulans*	FL	Texas	0.25 (K2) 0.37 (K2) 0.50 (K2)	a c d p	Bluegills held in wire boxes were not affected at the indicated concentrations. Water temperature was 58 F at the time of treatment, 49 F at drainage. Largemouth bass showed distress and some crappies died in waters treated with 0.33 ppm at 85 F. No deaths were noted in waters at 80 F.	Lowman (1965)
Banvel D	*Lepomis macrochirus*	BSA	–	(L) 410 (T2A) (G) 20 (T2A)* (G) 67.5 (T2A)** *vermiculite **attapulgite	a c d e g	Toxicity data for 24 and 48 hours are presented for liquid (L) and granular (G) formulations. Various commercial formulations were tested. The liquid formulations were almost invariably more toxic than the granular ones.	Hughes and Davis (1965)
Baron	*Onchorynchus tshawytscha* *Micropterus salmoides*	BSA	–	2.62 (T1A) 2.3 (T2A) 4.6 (T1A)	a c d e	Concentrations were based on percent active ingredient.	Bond, et al (1960)
Baron	Channel catfish (fingerlings)	BSA	–	7.2 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Bay 73 (WP 71)	*Micropterus salmoides*	BSA	–	0.05 (O) 0.10 (K1)	a e	At 0.05 ppm, 12 percent mortality occurred in 1 day. Experiments were carried out in fiber glass tubs filled with well water. Fish weights ranged from 2 to 6 pounds.	Mulla, et al (1967)
Bay 73 (WP 71)	*Micropterus salmoides* *Cyprinus carpio*	FL	Chino Fishery bass pond, Cal.	0.10 (O) 0.25 (K2) 0.10 (O) 0.25 (O)	a	For bass: At 0.10 ppm, no mortality occurred in 1 day. At 0.25 ppm, 50 percent mortality occurred in 1 day, and 100 percent occurred in 2 days. For carp: At 0.10 and 0.25 ppm, 10 percent mortality occurred.	Mulla, et al (1967)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Bayer 73	*Salmo gairdnerii*	BSA	–	0.052 (T2A)*	a c	Various temperatures (12 and 17 C) and water qualities in static bioassays did not influence the toxicity greatly, but pH variations in chemically buffered solutions did.	Marking and Hogan (1967)
	Salvelinus fontinalis			0.016 (T2A)*			
	Carassius auratus			0.279 (T2A)			
	Cyprinus carpio			0.139 (T2A)* 0.148 (T2A) 0.103 (T2A)			
	Pimephales promelas						
	Catastomus commersoni			0.081 (T2A)*			
	Ictiobus cyprinellus			0.064 (T2A)			
	Ictalurus melas			0.096 (T2A)* 0.084 (T2A)			
	I. punctatus						
	Pylodictis olivaris			0.043 (T2A)			
	Lepomis cyanellus			0.115 (T2A)			
	L. macrochirus			0.098 (T2A)* 0.082 (T2A)			
	L. microlophus			0.153 (T2A)			
	Micropterus dolomieui			0.089 (T2A)			
	M. salmoides			0.097 (T2A)			
	Perca flavescens			0.081 (T2A)*			
	Talapia mossambica			0.150 (T2A)			
	I. nebuilosus			0.071 (T2A) *12 C, other data at 17 C			
Bayer 73 (tech)	Rainbow trout	BSA	–	0.320 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
Bayer 73 (WP 71%)	*Gambusia affinis*	FL	Cal.	1.0 (K1)	–	Toxicity value is in lb/acre.	Mulla (1966)
Bayer 73 (tech)	*Pteronarcys californica* (naiads)	BSA	–	0.0002 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Bayer 4731	*Leiostomus xanthurus* (juvenile)	BSA	–	0.032 (O)	a	Water temperature was 13 C. The figure reported is a 48-hr EC_{50}.	Butler (1965)
Bayer 9018 (tech)	Rainbow trout	BSA	–	0.320 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)

Bayer 22408	*Anopheles quadrimaculatus*	BSA	—	0.04 (K1)	—	4th instar larvae of mosquitos were used in this bioassay. Adsorption was determined by use of P^{32} labeled Bayer 22488.	Schmidt and Weidhaas (1961)
Bayer 22408 (EC2)	*Gambusia affinis*	FL	Ponds in Ill.	(O)	—	When applied at 2.0 pounds per acre active ingredients, 12 percent fish mortality occurred in 1 day.	Mulla, et al (1963)
	Rana catesbeiana					No bullfrog mortality occurred at 2.0 pounds per acre in 1 day.	
Bayer 25198 (50 percent EC)	*Gambusia affinis*	FL	Ponds - Bakersfield, Cal.	(O)	a c	At 0.1 lb/acre, 4 percent mortality occurred in 24 hours. At 0.4 lb/acre, 8 percent mortality occurred in 24 hours. The experiments were conducted in cages placed in the ponds.	Mulla and Isaak (1961)
Bayer 25141 (50 percent EC)	*Gambusia affinis*	FL	Ponds - Bakersfield, Cal.	(O)	a c	At 0.2 lb/acre, 34 percent mortality occurred in 24 hours, and at 0.8 lb/acre, 100 percent kill occurred in 24 hours. The experiments were conducted in cages placed in the ponds.	Mulla and Isaak (1961)
Bayer 25141 (tech)	*Lepomis macrochirus*	BSA	—	0.056 (T4A)	a c d e f	The toxicity of this substance was not influenced by the the quality of the water (pH, hardness, alkalinity).	Pickering and Henderson (1966)
Bayer 29492 (EC2)	*Gambusia affinis*	FL	Ponds in Ill.	(O)	—	When applied at 0.2 pound per acre active ingredient, 100 percent mortality occurred in 1 day.	Mulla, et al (1963)
Bayer 29493 (Baytex)	*Carassius auratus* *Lepomis macrochirus* *Notemigonus crysoleugus*	BSCH	—	20 (O)* 20 (O)** * no response, 15 days ** response, 15 days	a c d e	Toxicity was determined by measuring acetylcholinesterase activity in the brains of fish. Concentrations are given in ppb as either response or not response in 15 or 30 days.	Weiss and Gakstatter (1964)
Bayer 29493	*Gammarus lacustris*	BSA	—	0.0138 (T4A)	a e	Emulsible concentrates were prepared from technical grade insecticides with acetone as the solvent. Symptoms prior to death were observed and recorded on graphs.	Nebeker and Gaufin (1964)
Bayer 29493 (tech, 93 percent active in acetone)	*Pteronarcys californica* (naiad) *Acroneuria pacifica* (naiad)	BSA	—	0.0265 (T4A) 0.0051 (T4A)	c d e f	*A. pacifica* was much more sensitive to chlorinated hydrocarbons and to organic phosphate insecticides than *P. californica*.	Jensen and Gaufin (1964)
Bayer 29493 (25 percent EC)	*Gambusia affinis*	FL	Ponds Bakersfield, Cal.	(O)	a c	At 0.1 lb/acre, 6 percent mortality occurred in 24 hours. At 0.4 lb/acre, 16 percent mortality occurred in 24 hours. The experiments were conducted in cages placed in the ponds.	Mulla and Isaak (1961)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Bayer 29493	*Chaoborus astictopus* *Lepomis macrochirus*	BSA	—	(O)	a	Tests were conducted on bluegill sunfish, *C. astictopus* first instar larvae, and fourth instar larvae, results on larvae were as follows: Fourth instar 0.007 (T1A) First instar 0.0043 (T1A)	Hazeltine (1963)
Bayer 29493 (tech)	Rainbow trout	BSA	—	0.760 (T4A)	—	The values reported are given as LC_{50}.	Cope (1965)
Bayer 29493 (Baytex)	*Procambarus simulans simulans*	BSA	—	0.18 (K1A)	a c d	Bioassays showed that concentrations to 5.6 ppm in 96 hr did not kill fingerling channel fish, largemouth bass, and redear sunfish.	Lowman (1965)
Bayer 29493	*Pteronarcys californica*	BSA	—	0.03 (T4A)	a	Unspecified chemical characteristics of assay water were determined by standard methods. General comments were made concerning "standardized" conditions, use of "soft" water, and use of emulsifying agents. Additional data are presented.	Gaufin, et al (1965)
	Acroneuria pacifica			0.005 (T4A)			
	Ephemerella grandis			0.02 (T4A)			
	Gammarus lacustris			0.01 (T4A)			
Bayer 29493	*Acroneuria pacifica*	BSA	—	0.005 (T4A)	a c	Additional TL_m data are given.	Gaufin, et al (1965)
	Ephemerella grandis			0.025 (T4A)			
	Gammarus lacustris			0.014 (T4A)			
	Pteronarchys californica			0.026 (T4A)			
Bayer 29493	*Acroneuria pacifica* *Pteronarcys californica*	BSA & CFCH	—	0.0051 (T4A) 0.00064 (T30A) 0.00265 (T4A) 0.00360 (T30A)	a c d e	Additional data are presented.	Jensen and Gaufin (1966)
Bayer 29493 (Baytex)	*Pimephales promelas*	BSA	—	3.3 (T4A)	a c d e f	The toxicity of this substance was not influenced by the quality of the water (pH, hardness, and alkalinity).	Pickering and Henderson (1966)
	Lepomis macrochirus			3.1 (T4A)			
	Lebistes reticulatus			3.1 (T4A)			
Bayer 29952 (EC2)	*Gambusia affinis* *Rana catesbeiana*	FL	Ponds in Ill.	(O)	—	When applied at 0.025 pound/acre active ingredient, 100 percent fish mortality occurred in 1 day. When applied at 0.4 pound/acre, 5 percent bullfrog mortality occurred in 1 day.	Mulla, et al (1963)
Bayer 30749 (EC4)	*Gambusia affinis*	FL	Ponds in Ill.	(O)	—	When applied at 0.8 pound/acre active ingredient, 100 percent fish mortality occurred in 1 day.	Mulla, et al (1963)

Bayer 34042 (EC4)	*Gambusia affinis* *Rana Catesbeiana*	FL	Ponds in Ill.	(O)	—	When applied at 0.025 pound/acre active ingredient, 100 percent fish mortality occurred in 1 day. No bullfrog mortality occurred at 0.4 pound/acre in 1 day.	Mulla, et al (1963)
Bayer 37289 (EC4)	*Gambusia affinis* *Bufo boreas* *Scophiopus hammondi*	FL	Ponds in Ill.	(O)	—	When applied at 0.8 pound/acre active ingredient, 52 percent fish mortality occurred in 1 day. No toad mortality occurred at 0.4 pound/acre in 1 day.	Mulla, et al (1963)
Bayer 37289	*Pteronarcys* sp (nymphs)	BSA	—	0.0001 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Bayer 37289	*Leiostomus xanthurus* (juvenile)	BSA	—	0.32 (O)	a	Water temperature was 13 C. The figure reported is a 48-hr EC_{50}.	Butler (1965)
Bayer 37289 (tech)	Rainbow trout	BSA	—	0.240 (T4A)	—	The values reported are given as LC_{50}.	Cope (1965)
Bayer 37289	*Pteronarcys californica* (naiads)	BSA	—	0.0001 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Bayer 37342 (EC4)	*Gambusia affinis*	FL	Ponds in Ill.	(O)	—	When applied at 0.4 pound/acre active ingredient, 24 percent mortality occurred in 1 day.	Mulla, et al (1963)
Bayer 37343 (EC2)	*Gambusia affinis*	FL	Ponds in Ill.	(O)	—	When applied at 0.025 pound/acre active ingredient, 0 percent mortality occurred in 1 day.	Mulla, et al (1963)
Bayer 37344 (tech)	Rainbow trout	BSA	—	0.640 (T4A)	—	The values reported are given as LC_{50}.	Cope (1965)
Bayer 37344	*Pteronarcys* sp (nymphs)	BSA	—	0.0054 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Bayer 37344	*Pteronarcys californica* (naiads)	BSA	—	0.0054 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Bayer 38156 (50 percent EC)	*Gambusia affinis*	FL	Ponds — Bakersfield, Cal.	0.1 (K1) 0.4 (K1)	a c	Toxicity values indicate application rates in lb/acre. The experiments were conducted in cages placed in the ponds.	Mulla and Isaak (1961)
Bayer 38156	*Leiostromus xanthurus* *Cyprinodon variegatus* *Mugil cephalus*	BCFCH	—	0.001 (O) 0.001 (O) 0.001 (O)	a	At a concentration of 0.001 ppm, the following percent acetylcholinesterase activity as compared to controls was found: *L. xanthurus* — 76 *C. variegatus* — 82 *M. cephalus* — 58	Butler and Johnson (1967)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Bayer 38819 (tech)	Rainbow trout	BSA	–	0.450 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
Bayer 38920 (EC4)	*Gambusia affinis* *Rana catesbeiana*	FL	Ponds in Ill.	(O)	–	When applied at 0.5 pound per acre active ingredient, 100 percent mortality of both species occurred in 1 day.	Mulla, et al (1963)
Bayer 41831 (EC4)	*Gambusia affinis* *Rana catesbeiana*	FL	Ponds in Ill.	(O)	–	When applied at 1.6 pounds per acre active ingredients, 44 percent fish mortality occurred in 1 day. No bullfrog mortality occurred at 0.8 pound per acre in 1 day.	Mulla (1963)
Bayer 41831	*Pteronarcys* sp (nymphs)	BSA	–	0.0038 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Bayer 41831 (tech)	Rainbow trout	BSA	–	0.700 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
Bayer 41831	*Cyprinodon variegatus* (juvenile)	BSA	–	(O)	a	Water temperature was 9 C. Fish showed irritation at 1.0 ppm.	Butler (1965)
Bayer 41831	*Pteronarcys californica* (naiads)	BSA	–	0.004 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Bayer 46676 (EC2)	*Gambusia affinis*	FL	Cal.	0.2 (K1)	–	Toxicity value is in lb/acre.	Mulla (1966)
Baygon	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	–	0.4 (O)	a	Stones heavily populated with larvae were placed in troughs of running water containing the toxicant. When the larvae became detached from the rocks and floated away, they assumed to have undergone lethal intoxication. The larvae were exposed to the toxicant for 5 minutes, then in clean water for 24 hours. At that time the number detached amounted to 83 percent.	Jamnback and Frempong-Boadu (1966)
Baygon	*Pteronarcys californica* (naiads)	BSA	–	0.013 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Baytex	*Salmo gairdnerii* (one wk old sac fry)	BSA	–	0.2 (K 0%) 2.0 (K 0%)	a e	Results are averages of triplicate tests. Toxicity is reported as percent mortality (K %).	Lewallen and Wilder (1962)
	(one mo old feeding fry)		–	0.2 (K 0%) 2.0 (K 0%)			

Baytex	*Culex pipiens quadrimaculatus*	BSA	–	(O)	c	Tests were conducted in tap water and artificially polluted tap water. The values reported are the concentration range for an LC90, 0.0015 to 0.0080 ppm in polluted and 0.0060 to 0.0160 in tap water.	Lewallen and Wilder (1963)
Baytex	*Pteronarcys* sp (nymphs)	BSA	–	0.0044 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Baytex	*Gambusia affinis*	BSA & FL	–	Not affected	a c	None of the fish showed overt symptoms of Baytex poisoning at a concentration of 0.025 ppm which is the equivalent of an application rate of 0.2 pound per acre. Some mortality occurred at 2.5 ppm concentration after 48 hours. There was little danger of acute poisoning to these species of fish when it was applied at 0.2 pound per acre. Long range effects of the chemical on other aquatic organisms were studied in plastic-lined ponds of 300 gallon capacity. Baytex was applied at 0.2 pound (tech) per acre. All of the *Cladocera* and chironomid population at 0.2 pound per acre were almost completely eliminated in the treated pond within a week. Copepods, ostracods, hydra, and annelid worms exhibited no noticeable population change.	Patten and Gillaspie (1966)
	Fundulus chrysotus			5 (K2)			
	Lepomis macrochirus			5 (K2)			
	Lepomis microlophus			5 (K2)			
	Chaenobryttus gulosus			5 (K2)			
Baytex	Oyster	BCF	–	1.0 (SB4)	a	Seawater was employed in this experiment.	Butler (1966)
Baytex	*Simocephalus serrulatus*	BSA	–	0.00092 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 48 hr. Data cited are for 60 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
	Daphnia pulex			0.00080 (SB)			
Ben Venue 35 (tech)	Rainbow trout	BSA	–	3.0 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
Ben Venue 3835 (tech)	Rainbow trout	BSA	–	0.380 (T4A)	–	Comment same as above.	Cope (1965)
Ben Venue 54 (tech)	Rainbow trout	BSA	–	0.480 (T4A)	–	Comment same as above.	Cope (1965)
Benzene hexachloride	Bluegill	BSA	–	0.45 (SB)	(O)	Bluegills tolerated concentrations of 0.45 ppm. A field study is also described.	Linduska and Surber (1948)
a-benzene hexachloride	*Microcystis aeruginosa*	L	–	50 (K)	a	The chemical was tested on a 5 day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
Benzene hexachloride (various isomers, tech)	Lymnaeid snails	BSA	–	(O)	–	Each test container (500-ml beaker) was filled with ditch water. Less than 100% mortality occurred in concentrations of 1:100,000.	Batte, et al (1951)
Benzene hexachloride (gamma-isomer, 5 percent)	Lymnaeid snails	BSA	–	(O)	–	Each test container (500 ml-beaker) was filled with ditch water. 100% mortality occurred in concentrations of 1:600,000 and greater.	Batte, et al (1951)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Benzene hexachloride (99.8 percent isomer)	Lymnaeid snails	BSA	–	(O)	–	Each test container (500 ml-beaker) was filled with ditch water. 100% mortality occurred in concentrations of 1:600,000 and greater.	Batte, et al (1951)
Benzene hexachloride	*Oncorhynchus kisutch* (fry)	FL	Sproat Lake, Canada	(O)	–	Tests were in fresh water and seawater. No difference in toxicity was observed due to water type. The chemical was sprayed as an emulsion from a plane, at the rate of 12.3 lb per 34,848 sq ft. The fish were exposed in boxes submerged in the water. At a concentration of 1.38 ppm., 5 of 15 fish survived 15 minutes; at 0.36 ppm 3 of 15 survived 32 minutes; at 0.031 ppm, 3 of 15 survived 105 minutes; at 0.034 ppm all fish were dead in 10 hours. The calculated initial concentration of 6.0 ppm had decreased to 1.38 in 15 minutes, and to 0.081 in 105 minutes, and 0.34 ppm in 10 hours. It is interesting that fish held more than a foot below the surface were unharmed.	Jackson (1960)
Benzene hexachloride (alpha isomer)	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – NT Ma – NT So – NT Cv – NT Gp – NT Np – NT	Palmer and Maloney (1955)
Benzene hexachloride (beta isomer)	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Comment same as above except that: Cl – PT (7) Ma – PT (7) So – NT Cv – NT Gp – NT Np – NT	Palmer and Maloney (1955)

Benzene hexachloride (delta isomer)	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Comment same as above except that: Cl – NT Ma – PT (7) So – PT (7) Cv – NT Gp – T Np – PT (14)	Palmer and Maloney (1955)
Benzene hexachloride (gamma isomer)	Black fly (larvae) Rainbow trout Caddisfly	FR	Alaskan streams	0.5 (O) 10 (O) 10 (O)	–	The chemical was applied for control of black flies, and because the acetone solution was most effective, only that data is reported here. The figures reported are for minimum effective dosages for black fly larvae and maximum nonlethal dosages for rainbow trout and caddisfly larvae. The value given for black flies was the highest dosage tested and was ineffective.	Gjulian, et al (1949)
Benzene hexachloride (gamma isomer)	*Lepomis macrochirus*	B	Auburn, Ala.	0.1 to 2.0 (K)	–	Aquarium test.	Lawrence (1950)
	Micropterus salmoides	F		0.1 to 0.2 (K)		In an earthen pond, 0.18 ppm failed to kill bluegill, bass, golden shiner and several species of minnows.	
Benzene hexachloride (gamma isomer)	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella Variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – NT Ma – NT So – NT Cv – NT Gp – NT Np – NT	Palmer and Maloney (1955)
Benzene hexachloride (gamma isomer, tech)	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Comment same as above except that: Cl – NT Ma – PT So – PT (14) Cv – NT Gp – PT Np – NT	Palmer and Maloney (1955)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
BHC	Black fly (larvae)	F	Alaskan streams	0.5 (O)	–	The chemical was applied for control of black flies, and because the acetone solution was most effective, only that data is reported here. The figures reported are for minimum effective dosages, for black fly larvae and maximum non-lethal dosages for rainbow trout and caddisfly larvae. The value given for black flies was the highest dosage tested, and was ineffective.	Gjulian, et al (1949)
	Rainbow trout			5.0 (O)			
	Caddisfly			0.5 (O)			
BHC	Blue crab	FE	Bombay Hook Island, Del.	(O)	–	The location under study was a salt marsh bounded by Delaware Bay. Organisms were confined in cages within the test area. BHC was applied at 0.1 pound per acre. *C. variegatus*, *L. xanthurus*, and *M. curema* showed 35 percent mortality in 7 days. Blue crabs showed 10 percent mortality when exposed for 7 days in streams and 10 percent mortality in ponds. Marsh fiddler crabs and red-jointed fiddler crabs showed mortalities of 80 and 35 percent, respectively, in 7 days.	George, et al (1957)
	Marsh fiddler crab			(O)			
	Red-jointed fiddler crab			(O)			
	Cyprinodon variegatus			(O)			
	Leiostomus xanthurus			(O)			
	Mugil curema			(O)			
BHC	Fathead minnow	BSA	–	2.3 (T4A)	a	It was the authors opinion that pH, alkalinity and hardness, within the usual range in natural waters, had little effect on the toxic effect of the compounds studied. The values given are from Henderson, Pickering, and Tarzwell, "The Relative Toxicity of Ten Chlorinated Hydrocarbon Insecticides to Four Species of Fish". It is interesting that the different tables from the above book (as reported in this paper) report widely different values for the same compounds. This experiment was performed in soft water.	Tarzwell (1959)
	Bluegill			0.79 (T4A)			
	Goldfish			2.3 (T4A)			
	Guppy			21.7 (T4A)			
BHC	Fathead minnow	BSA	–	2.0 (T4A)	a	Comment same as above.	Tarzwell (1950)
BHC	*Pimephales promelas*	BSA	–	2.30 (T4A)	a d e f	Concentrations were based on percent active ingredient.	Henderson, et al (1959)
	Lepomis macrochirus			0.79 (T4A)			
	Carassius auratus			2.3 (T4A)			
	Lebistes reticulatus			2.17 (T4A)			
BHC	*Pimephales promelas*	BSA	–	2.3 (T4A)	a	Bioassay investigations of the new insecticides indicate that in general the organic phosphorus compounds are not as toxic to fish as are the chlorinated hydrocarbons. The toxicity of most of these materials was not significantly influenced by water quality. Therefore it is to be expected that the toxicity of these materials will not differ significantly in different streams.	Tarzwell (1959)
	Lepomis macrochirus			0.79 (T4A)			

BHC	Algae *Salmo trutta* Invertebrates	FR	Isle of Man, Eng.	–	–	Report notes that the fish were not killed, but may have moved from polluted areas when their normal insect food was no longer available. Tables give percentage composition of fauna at 8 collecting stations, given in yards above and below point of origin.	Hynes (1961)
BHC	–	FR	Flint Creek, Ala.	0.456 (K)	–	Conventional treatment in a water purification plant did not reduce the amount of chemical found in the stream. Data are given for 4 years 1959-1962, with a range of concentrations. Only the highest value is reported here. Some fish kill is reported, but species are not identified here. Data for different seasons are reported. The one listed here is for summer 1961.	Nicholson, et al (1964)
BHC	*Heteropneustes fossilis*	BSA	–	(O)	–	Experiments were conducted in a small battery jar containing 5 liters of water sprayed with 25 cc of BHC (20%). The fish died in 1 hour and 30 min.	Mathur (1964)
BHC	Bluegill	BSA	–	0.79 (T4A)	a	Assays were conducted in soft water at 25 C. Decrease in brain cholinesterase was measured in fish exposed to the toxicant.	Weiss (1964)
BHC	Golden shiner *Cyclops* sp	BSA	–	0.062-1.5 (O) 0.062-0.5 (O)	a c d e p	The 1.5 ppm value cited is for a 2-day period with the active ingredient added as a wettable powder to water. Threshold values, (LD/O) for the BHC dissolved in a number of solvents were somewhat lower. Some of the solvents caused a 25-fold increase in toxicity of BHC to golden shiner. A TL_m 48 hr of 0.125-0.25 ppm BHC was obtained for *Cyclops*. Formulations containing oil were more toxic than dust formulations of BHC.	Meyer (1965)
BHC	*Tubifex* spp *Limnodrilus* spp	BSA	–	3.0-15 (L4A)	a c e	Toxicity is reported as the mean lethal dose (LD_{50}) for 24, 48, and 96 hours.	Whitten and Goodnight (1966)
BHC	*Puntius puckelli*	BSA	–	3.8 (T4A)	a c d e l m	Tap water was used as diluent. Toxicity data are given as TL_m's in ppm for 24, 48, 96 hr. The pH of the water averaged 8.3. The study was conducted in India.	Rao, et al (1967)
BHC	*Oncorhynchus kisutch*	BSA	–	0.2 (T2A)	a	The rate of decay of the gamma isomer of BHC is suspected to be appreciable. The half-life in fresh water would be somewhere in the vicinity of 7-8 days.	Velsen and Alderdice (1967)
BHC (crude)	*Sesarma africanum*	BSA	–	65 (K<1) 6.5 (K1) 0.65 (SB) 0.065 (NTE)	– – – –	BHC caused complete lack of coordination within 24 hours.	Jordan (1955)
		FR	Sierra Leone	325	–	In rice fields, sprays with as low as 325 ppm BHC gave adequate protection from crabs to young rice seedlings. Initial results given were derived from contact with aqueous suspensions of varying concentrations in bioassay evaluations.	
BHC (emulsion)	*Micropterus salmoides* (fry) *Ictalurus punctatus* (fry) *Lepomis macrochirus* (fry)	BSA	–	0.05 (SB3) 0.2 (SB3) 0.1 (SB3)	a c d e f p	At least 90 percent of the fry survived for a period of 72 hours at the concentration listed.	Jones (1965)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
BHC (45% gamma isomer)	Oyster	BCF	–	1.0 (O)	a	The value reported is a 96-hr EC_{50} (decreased shell growth).	Butler (1965)
BHC (45% gamma isomer)	Oyster	BCF	–	0.36 (O)	a	The value reported is a 96-hr EC_{50} (decreased shell growth).	Butler (1965)
BHC (tech, 15.5%)	*Pimephales promelas*	BSA	–	15 (T4A)	a b e c d f	Dilution water was usually soft although some studies were conducted with hard water.	Henderson, et al (1959)
	Lepomis macrochirus			5.1 (T4A)			
	Carassius auratus			15 (T4A)			
	Lebistes reticulatus			14 (T4A			
BHC (WP)	*Micropterus salmoides* (fry)	BSA	–	0.2 (SB3)	a c d e f	At least 90 percent of the fry survived for a period of 72 hours at the concentration listed.	Jones (1965)
	Ictalurus punctatus (fry)			0.4 (SB3)			
	Lepomis macrochirus (fry)			0.5 (SB3)			
Bidrin (tech)	*Procambarus clarki*	BSA	–	3.0 (T3A)	a c d o	There was no detectable difference in toxicity to male or female crawfish.	Muncy and Oliver (1963)
Bidrin	*Pteronarcys californica* (naiads)	BSA	–	0.43 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Bomyl (EC_4, GC-3707)	*Gambusia affinis*	FL	Cal.	(O)	–	At an application rate of 2.0 lb/acre, 66% mortality of the fish occurred in 24 hours.	Mulla (1966)
Borate	*Salmo gairdnerii*	BSA	–	2300 (T1A) 2050 (T2A)	a e	Most of the weed-killer formulations in this study consisted of more than one substance, i.e., oils, emulsifiers, stabilizers, and other adjuvants.	Alabaster (1956)
BP 1002	*Pandalus montagui*	BSA	–	5.8 (T2A)	a e	Experiments were conducted in tanks holding 10 liters of seawater at 15 C. It was shown that the toxicity of this solvent emulsifier decreased with time due to evaporation of the solvent. BP 1002 at a concentration of 3.3 ppm killed 100% of *Crangon crangon* larvae in 3 hr; at 10 ppm it killed 95% of *Carcinus maenas* in 3 hr.	Portmann and Connor (1968)
	Crangon crangon			5.8 (T2A)			
	Carcinus maenas			15.0 (T2A)			
	Cardium edule			81.0 (T2A)			
Buramine	*Semotilus atromaculatus*	BSA	–	1,000 to 1,500 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)

C-56	*Lepomis macrochirus* *Micropterus salmoides*	BSA	–	30 (T2A) 35 (T2A)	a c o	The response of bluegill and bass fingerlings to nine agricultural chemicals as determined by bioassay using river water is presented in this report. Bluegills were more tolerant of the chemicals tested than bass.	Davis and Hardcastle (1959)
C-2059	*Lepomis macrochirus*	BSA	–	55 (T1A)	a b e	This report is a simple and straightforward determination of a median tolerance limit for a selected group of herbicides.	Hughes and Davis (1967)
C-2059	*Lepomis macrochirus*	BSA	–	90 (T1A)	a b e	Comment same as above.	Hughes and Davis (1967)
C-8514	*Oncorhynchus kisutch*	BSA	–	21.5 (T2A)	a	Physical instability of this formulation would suggest that toxicity in the aquatic environment could be a problem if the preparation is to be used in or near water courses under field conditions.	Velsen and Alderdice (1967)
Camphene (chlorinated)	Silverling minnows Spotfin shiner Creek chub Fall fish Blacknosed dace	BSA	–	0.04 (K)	–	The "Threshold" for bluegills was 0.01 ppm. A field study in W. Va. is also described.	Linduska and Surber (1948)
Captan (N-trichloro-methylthio-4-cyclohexene-1,2-dicarboxyimide)	*Brachydanio rerio* (larvae)	BSA	–	30 (T1A) 1.0 (O) (T 70 min)	a	TL_m was 70 min for larvae. Ninety-eight percent of the larvae died in 90 min.	Dawood and Dazo (1966)
Carbaryl	*Procambarus clarkii*	FO	Crowley La.	(O)	c d e p	Experiment was conducted in a flooded rice field Area was divided into 4 blocks with a fence restricting crawfish to the desired area. The rearing of crawfish in rice fields is of considerable commercial importance in Louisiana. It is fortunate that the chemicals discussed in this report had no untoward effect at the levels used. The chemical was applied at the rate of 0.8 lbs/acre.	Hendrick, et al (1966)
Carbaryl	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	–	0.4 (O)	a	Stones heavily populated with larvae were placed in troughs of running water containing the toxicant. When the larvae became detached from the rocks and floated away, they were assumed to have undergone lethal intoxication. The larvae were exposed to the toxicant for 5 minutes, then in clean water for 24 hours. At that time the number detached amounted to 47 percent.	Jamnback and Frempong-Boadu (1966)
Carbaryl	*Australorbis glabratus*	BSA and FL	Puerto Rico	(O)	c	Seven of the tested compounds failed to meet acceptability criteria—that is, complete kill after 6-hr exposure to 10 ppm. They were not used in field tests. Field tests showed WL 8008 to be highly effective. All others failed.	Seiffer and Schoof (1967)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Carbaryl	*Pteronarcys californica* (naiads)	BSA	–	0.0048 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1963)
	Pteronarcella badia (naiads)			0.0017 (T4A)			
	Claasenia sabulosa (naiads)			0.0056 (T4A)			
Carbo-phenothion (Trithion)	*Culex pipiens quadrimaculatus*	BSA	–	(O)	c	Tests were conducted in tap water and artifically polluted tap water. The values reported are the concentration range for an LC_{90}, 0.085 to 0.280 ppm for polluted, and 0.017 to 0.034 ppm for tap water.	Lewallen and Wilder (1963)
Carbo-phenothion (EC4)	*Gambusia affinis*	FL	Ponds in Ill.	(O)	–	When applied at 0.2 and 1.6 pounds per acre active ingredient, 98 and 100 percent fish mortality occurred respectively in 1 day.	Mulla, et al (1963)
	Rana catesbeiana					When applied at 0.4 pound per acre, 100 percent bullfrog mortality occurred in 1 day.	
Carbo-phenothion (EC4)	*Micropterus salmoides*	BSA	–	1.0 (O)	a e	At 1.0 ppm, 10 percent mortality occurred in 1 day. Experiments were carried out in fiber glass tubs filled with well water. Fish weights ranged from 2 to 6 pounds.	Mulla, et al (1967)
Casoron	Redear sunfish	BSA	–	(O)	a	No mortality was noted in fish weighing 3 g with concentrations of 20,000 mg/1 at 48 hr.	Cope (1963)
Casoron	*Pteronarcys* sp (nymphs)	BSA	–	6.6 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Casoron	*Simocephalus serrulatus*	BSA	–	5.8 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
	Daphnia pulex			3.7 (SB)			
Casoron	Rainbow trout	BSA	–	22 (T2A)	–	Data are given as LC_{50}.	Bohmont (1967)
	Bluegill			20 (T2A)			
Casoron (WP)	Rainbow trout	BSA	–	18 (T4A)	a	This is an estimated LC_{50} value at temperatures from 55 to 75 F.	Cope (1965)
	Bluegill			10 (T4A)			
Catechol	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1×10^6 to 2×10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
Ceresan M	Channel catfish (fingerlings)	BSA	–	1.8 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)

Chem Ban	Channel catfish (fingerlings)	BSA	—	26 (K1A)	a	Comment same as above.	Clemens and Sneed (1959)
Chem Fish Special	Channel catfish (fingerlings)	BSA	—	0.56 (K1A)	a	Comment same as above.	Clemens and Sneed (1959)
Chem Mite	Channel catfish (fingerlings)	BSA	—	1.29 (K1A)	a	Comment same as above.	Clemens and Sneed (1959)
Chem Sen 56	Channel catfish (fingerlings)	BSA	—	97.7 (K 30 hr A)	a	Comment same as above.	Clemens and Sneed (1959)
Chemagro	*Leiostomus xanthurus* (juvenile)	BSA	—	0.032 (O)	a	Water temperature was 21 C. The figure reported is a 48-hr EC_{50}.	Butler (1965)
Chemagro 4497	*Leiostomus xanthurus* (juvenile)	BSA	—	0.032 (O)	a	Comment same as above.	Butler (1965)
Chlorax	Channel catfish (fingerlings)	BSA	—	3157 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Chlordane	Bluegill	F	—	(O)	—	At 1 lb per acre, 87 percent of the bluegill sunfish were killed. At 0.5 lb per acre most of the bluegills as well as other species survived.	Linduska and Surber (1948)
Chlordane	Black fly (larvae) Rainbow trout Caddisfly	FR	Alaskan streams	0.5 (O) 20 (O) 10 (O)	—	The chemical was applied for control of black flies, and because the acetone solution was most effective, only that data is reported here. The figures reported are for minimum effective dosages of black fly larvae and maximum nonlethal dosages for rainbow trout and caddisfly larvae. The value given for black flies was the highest dosage tested. The value given for trout was also the highest tested.	Gjulian, et al (1949)
Chlordane	*Lepomis macrochirus* *Carassius auratus* *Micropterus salmoides*	BSA	Auburn, Ala.	0.1 (NTE) 0.2 (K)	—	At this concentration, there was no apparent effect. At this concentration, bluegill and bass were killed, but goldfish survived.	Lawrence (1950)
Chlordane	Fathead minnow Bluegill Goldfish Guppy	BSA	—	0.052 (T4A) 0.022 (T4A) 0.082 (T4A) 0.19 (T4A)	a	It was the authors opinion that pH, alkalinity and hardness, within the usual range in natural waters, had little effect on the toxic effect of the compounds studied. The values given are from Henderson, Pickering, and Tarzwell, "The Relative Toxicity of Ten Chlorinated Hydrocarbon Insecticides to Four Species of Fish". It is interesting that the different tables from the above book (as reported in this paper) report widely different values for the same compound. This experiment was performed in soft water.	Tarzwell (1959)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Chlordane	Fathead minnow	BSA	–	0.069 (T4A)	a	It was the authors opinion that pH, alkalinity and hardness, within the usual range in natural waters, had little effect on the toxic effect of the compounds studied. The values given are from Henderson, Pickering, and Tarzwell, "The Relative Toxicity of Ten Chlorinated Hydrocarbon Insecticides to Four Species of Fish". It is interesting that the different tables from the above book (as reported in this paper) report widely different values for the same compounds. The experiment was performed in hard water.	Tarzwell (1959)
Chlordane	Channel catfish (fingerlings)	BSA	–	0.74 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Chlordane (100%)	*Pimephales promelas*	BSA	–	0.069 (T4A)	a b e c d f	Dilution water was usually soft although some studies were conducted with hard water.	Henderson, et al (1959)
	Lepomis macrochirus			0.022 (T4A)			
	Carassius auratus			0.082 (T4A)			
	Lebistes reticulatus			0.19 (T4A)			
Chlordane	*Pimephales promelas*	BSA	–	0.05 (T4A)	a d e f	Concentrations were based on percent active ingredient.	Henderson, et al (1959)
	Lepomis macrochirus			0.01 (T4A)			
	Carassius auratus			0.08 (T4A)			
	Lebistes reticulatus			0.19 (T4A)			
Chlordane (75%)	*Pimephales promelas*	BSA	–	0.18 (T4A)	a b e c d f	Dilution water was usually soft although some studies were conducted with hard water.	Henderson, et al (1959)
Chlordane	*Pimephales promelas*	BSA	–	0.052 (T4A)	a	Bioassay investigations of the new insecticides indicate that in general the organic phosphorus compounds are not as toxic to fish as are the chlorinated hydrocarbons. The toxicity of most of these materials was not significantly influenced by water quality. Therefore it is to be expected that the toxicity of these materials will not differ significantly in different streams.	Tarzwell (1959)
	Lepomis macrochirus			0.022 (T4A)			
Chlordane	*Oncorhynchus kisutch*	BSA	–	56 (T4A)	a c d e	Chemical dissolved in acetone. TL_m expressed in ppb.	Katz (1961)
	Oncorhynchus tshawytscha			57 (T4A)			
	Salmo gairdnerii			44 (T4A)			
	Gasterosteus aculeatus			90 (T4A)			

Chlordane	*Gammarus lacustris lacustris*	BSA	–	(O)	a e p	The mortality might have been partially due to the susceptibility of the organism to higher temperatures, toxicity from extended exposure to copper electrodes (used to shock the organism to determine death), or the increase of CO_2. Results were expressed as LT_{50}; for example, at 0.5 ppm, 50 percent of the shrimp were killed in 235 (±35) min.	McDonald (1962)
Chlordane (EC 7.5)	*Gambusia affinis* *Rana catesbeiana* (tadpoles)	FL	Cal.	0.5 (O)	a c	Mixed populations of the indicated test species contained in cages were exposed to various insecticidal chemicals applied as dilute sprays to ponds 1/16 acre in size. The indicated toxicant concentration is in lb/acre, and resulted in a 70 percent mortality for the fish, and a 0 percent mortality for the tadpoles in 24 hr.	Mulla (1963)
Chlordane	Bluegill	BSA	–	0.022 (T4A)	a	Assays were conducted in soft water at 25 C. Decrease in brain cholinesterase was measured in fish exposed to the toxicant.	Weiss (1964)
Chlordane	*Pteronarcys* sp (nymphs)	BSA	–	0.015 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Chlordane (tech)	Rainbow trout Bluegill	BSA	–	0.0078 (T4A) 0.040 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
Chlordane	*Simocephalus serrulatus* *Daphnia pulex*	BSA	–	0.020 (SB) 0.029 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 48 hr. Data cited are for 60 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
Chlordane (75% emulsion)	Green sunfish	BSA	–	1.0 (NTE)	–	Fish were repelled by concentrations of 5, 10, and 20 ppm. No lethal effects were noted at concentrations less than 5 ppm.	Summerfelt and Lewis (1967)
Chlordane	Vascular plants Algae Chubs Largemouth bass Clams	FL	Tule Lake, Ore.	(O)	–	The amount of chemical applied as a spray was not specified. Plants contained 1.5 to 6.0 ppb. Algae contained 1.7 to 50.0 ppb. Chubs were analyzed to show a content of 8.0 to 24.0 ppb. Bass contained 7.5 to 43.0 ppb. Clams contained 2.0 to 25.0 ppb. The water contained 0.01 to 0.51 ppb.	Godsil and Johnson (1968)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Chlordane	*Labeo rohita* *Chamna punctatus* *Mastocembelus pancalus* *Trichogaster fasciatus* *Mystus vittatus* *Nandus nandus* *Puntius sophore* *Heteropneustes fossilis* *Amphipnous cuchia* Phytoplankton: *Volvox, Pandorina, Closterium*	BSA	—	0.0000709 (T7A) 0.0001 (K 40 hr) 0.001 (K 115 hr) 0.0001 (T7) 0.0008 (T7) 0.0016 (K 51 hr) 0.002 (K 130 hr) 0.00032 (T7) 0.002 (K 60 hr) 0.001 (T7) 0.0025 (K 25 hr) 0.0008 (T7) 0.005 (K 18 hr) 0.0008 (T7) 0.005 (K 51 hr) 0.001 (T7) 0.08 (K 45 hr) 0.01 (T7) 0.001 to 0.50 (K7)	a e	Chlordane was found to be highly toxic but not selective to fish. Its prolonged toxicity makes it unsuitable for fishery management and it is recommended that chlordane not be used in fields adjacent to fishery reservoirs.	Konar (1968)
	Zooplankton: *Cyclops* *Nauplius* *Daphnia* *Cypris* *Ceriodaphnia* *Diaptomus* *Gastrotrica* *Brachionus*			0.10 to 0.50 (K7)		*Gastrotrica* were not affected and *Brachionus* was not killed at 0.10 ppm.	
Chlordane	*Pteronarcys californica* (naiads)	BSA	—	0.015 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Chlorea (granular)	*Althemanthera philoxeroides* *Najas quadalupensis* Spatterdock	FL	Fla.	(O)	—	The degree of control was as follows: *A. philoxeroides* (393 lb/acre) — 30 percent *N. quadalupensis* (393 lb/acre) — none spatterdock (454 lb/acre) — 2 percent	Copeland and Woods (1959)

Chloretone	*Brachydanio rerio* (fertilized eggs, 2 hr)	BSA	–	100* (K 37 min) 50* (K 3-1/4 hr) 10* (K 5 hr) 5* (SB 1-1/2 hr) 1* (NTE)	a	Saturated solutions and dilutions of saturated solutions were used. 4.5 g of the chemical saturated 500 ml of water at RT. Percent dilutions used were 100, 50, 10, 5.0, 4.0, 3.0, 2.0, and 1.0. Immobilization times are given. Histological observations were also made.	Blumenkrantz (1956)
	(fertilized eggs, 24 hr)			100* (K 37 min) 50* (K 7-1/2 hr) 10* (K 119 hr) 5* (SB 1-1/2 hr) 1* (NTE) *% of saturated solution			
Chlorophenyl	*Salmo gairdnerii*	BSA	–	975 (T1A) 925 (T2A)	a e	Most of the weed-killer formulations in this study consisted of more than one substance, i.e., oils, emulsifiers, stabilizers, and other adjuvants.	Alabaster (1956)
Chlorothion	*Pimephales promelas*	BSA	–	3.3 (T4A)	a c d e f	Tests were performed in both hard and soft water. Additional tolerance limit values are given.	Henderson and Pickering (1958)
Chlorothion	Fathead minnow	BSA	–	3.2 (T4A)	a	It was the authors opinion that pH, alkalinity and hardness, within the usual range in natural waters, had little effect on the toxic effect of the compounds studied. The values given are from Henderson, Pickering, and Tarzwell, "The Relative Toxicity of Ten Chlorinated Hydrocarbon Insecticides to Four Species of Fish". It is interesting that the different tables from the above book (as reported in this paper) report widely different values for the same compounds. This experiment was performed in hard water.	Tarzwell (1959)
Chlorothion	*Pimephales promelas*	BSA	–	3.2 (T4A)	a	Bioassay investigations of the new insecticides indicate that in general the organic phosphorus compounds are not as toxic to fish as are the chlorinated hydrocarbons. The toxicity of most of these materials was not significantly influenced by water quality. Therefore it is to be expected that the toxicity of these materials will not differ significantly in different streams.	Tarzwell (1959)
Chlorothion	*Pimephales promelas*	BSA	–	3.2 (T4A)	a d e f	Concentrations were based on percent active ingredient.	Henderson, et al (1959)
Chlorothion	*Lepomis macrochirus* *Micropterus salmoides* *Notemigonus crysoleucas* *Carassius auratus*	BSA	–	0.1 (O) 0.1 (O) 0.1 (O) 0.1 (O)	a c d f	This paper reports the effect of insecticides in reducing the anticholinesterase in a fish brain within 2-8 hours. The inhibition of the enzyme was a function of the concentration of the insecticide, extent of exposure, and specific chemical nature of the compound.	Weiss (1959)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Chlorothion	*Pimephales promelas*	BSA	–	0.5 (O)	–	The degree of reaction to the cholinesterase-inhibiting insecticides is not only a function of time and concentration, but also of chemical and biological species. This paper reports many analyses of brain cholinesterase activity which is expressed as percentage of normal. The data are reported as LT_{50} which was the time required for 0.5 ppm of the chemical to kill 50 percent of the fish. The LT_{50} for the fathead was 72 hr.	Weiss (1961)
Chlorothion (tech, 98 percent)	*Pimephales promelas*	BSA	–	2.8 (T4A)	a c d e	Soft water primarily was the test medium. TL_m's reported for 24, 48, and 96 hr. Acetone or alcohol used as solvent or carrier in most cases.	Pickering, et al (1962)
	Lepomis macrochirus			0.71 (T4A)			
	Carassius auratus			2.3 (T4A)			
	Lebistes reticulatus			1.2 (T4A)			
Chlorothion	*Carassius auratus* *Lepomis macrochirus* *Notemigonus crysoleucus*	BSCH	–	1.0 (O)* * no response, 15 days	a c d e	Toxicity was determined by measuring acetylcholinesterase activity in the brains of fish. Concentrations are given in ppb as either response or not response in 15 or 30 days.	Weiss and Gakstatter (1964)
Chlorothion	Bluegill	BSA	–	0.7 (T4A)	a	Assays were conducted in soft water at 25 C. Decrease in brain cholinesterase was measured in fish exposed to the toxicant.	Weiss (1964)
Chloroxuron (granular)	*Lepomis macrochirus*	BSA	–	60 (T1A)	a b e	This report is a simple and straightforward determination of a median tolerance limit for a selected group of herbicides.	Hughes and Davis (1967)
Chloroxuron (WP)	*Lepomis macrochirus*	BSA	–	25 (T1A)	a b e	Comment same as above.	Hughes and Davis (1967)
CIPC	*Lepomis macrochirus*	BSA	–	12 (T2A)	a c o	This response of bluegill and bass fingerlings to nine agricultural chemicals as determined by bioassay using river water is presented in this report. Bluegills were more tolerant of the chemicals tested than bass.	Davis and Hardcastle (1959)
	Micropterus salmoides			10 (T2A)			
Cleanosol	*Pandalus montagni*	BSA	–	32 (T2A)	a e	Experiments were conducted in tanks holding 10 liters of of seawater at 25 C. It was shown that the toxicity of this solvent emulsifier decreased with time, due to evaporation of the solvent. Cleansol at a concentration of 33.3 ppm killed 100% of *Crangon crangon* larvae in 3 hr.	Herbert, et al (1965)
	Crangon crangon			44 (T2A)			
	Carcinus maenas			102 (T2A)			
	Cardium edule			19.2 (T2A)			

Clostridium botulinum (Type A toxin)	*Pimephales promelas*	BSA	–	(O)	a c d e	Fish survived high does rates of 102,000 mouse LD_{50}/ml for 24 hr and 17,000 mouse LD_{50}/ml for 96 hr. Fish cannot be used to detect this chemical at levels critical for man.	Pickering and Henderson (1959)
CMU	Algae (Mixed culture) *Lepomis macrochirus* *Lepomis cyanellus* *Pomoxis nigromaculatus* *Hyborhyncus notatus* *Lebistes* spp	LBSA	–	0.5-1.0 (K) (O)	a e	Tests with 22 species of algae indicated that 0.5 to 1.0 ppm CMU prevented growth. No adverse effects on the fish were found in 23 days with concentrations of 10, 20, and 40 ppm.	Fitzgerald (1958)
CMU	Channel catfish (fingerlings)	BSA	–	75.9 (K 25 hr A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Conco LCP-12	*Daphnia magna*	BSA	–	694 (T1A) 290 (T2A) 204 (T3A)	e	When emulsifier was mixed with crude oil, the TL_m value was one-half the values cited.	Dowden (1962)
Co-ral	*Pimephales promelas* *Lepomis macrochirus*	BSA	–	>18 (T4A) 0.18 (T4A)	a d e f	Concentrations were based on percent active ingredient.	Henderson, et al (1959)
Co-ral	*Pimephales promelas* *Lepomis macrochirus*	BSA	–	>18 (T4A) 0.18 (T4A)	a	Bioassay investigations of the new insecticides indicate that in general the organic phosphorus compounds are not as toxic to fish as are the chlorinated hydrocarbons. The toxicity of most of these materials was not significantly influenced by water quality. Therefore it is to be expected that the toxicity of these materials will not differ significantly in different streams.	Tarzwell (1959)
Co-Ral	*Oncorhynchus kisutch* *Salmo gairdnerii* *Gasterosteus aculeatus*	BSA	–	15,000 (T4A) 1,500 (T4A) 1,862 (T4A)	a c d e	Chemical dissolved in acetone. TL_m expressed in ppb.	Katz (1961)
Co-Ral	*Micropterus salmoides* *Pimephales promelas*	BSA	–	0.5 (O) 0.5 (O)	–	The degree of reaction to the cholinesterase-inhibiting insecticides is not only a function of time and concentration, but also of chemical and biological species. This paper reports many analyses of brain cholinesterase activity which is expressed as percentage of normal. The data are reported as LT_{50} which was the time required for 0.5 ppm of the chemical to kill 50 percent of the fish. For bass the LT_{50} was 36 hr and for the fathead 72 hr.	Weiss (1961)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Co-Ral (tech, 97.5 percent)	*Carassius auratus*	BSA	–	18 (T4A)	a c d e	Soft water primarily was the test medium. TL$_m$'s reported for 24, 48, and 96 hr. Acetone or alcohol used as solvent or carrier in most cases.	Pickering, et al (1962)
	Lebistes reticulatus			0.56 (T4A)			
Co-Ral	*Chaoborus astictopus*	BSA	–	0.39 (T1A)	a	Toxicity value given is for the fourth instar larvae.	Hazeltine (1963)
Co-Ral	*Carassius auratus*	BSCH	–	1.0 (O)*	a c d e	Toxicity was determined by measuring acetylcholinesterase activity in the brains of fish. Concentrations are given in ppb as either response or not response in 15 or 30 days.	Weiss and Gakstatter (1964)
	Lepomis macrochirus			1.07 (O)**			
	Notemigonus crysoleucus			1.0 (O)* * no response, 15 days **response, 15 days			
CO-RAL	*Cyprinodon variegatus* (juvenile)	BSA	–	0.28 (O)	a	Water temperature was 12 C. The figure reported is a 48-hr EC$_{50}$.	Butler (1965)
Co Ral	*Salmo gairdenerii*	BSA	–	0.55 (T2A)	a f	Variance and the 95-percent confidence interval (C.I.) were also determined.	Willford (1966)
	Salmo trutta			0.73 (T2A)			
	Salvelinus fontinalis			0.8 (T2A)			
	Salvelinus namaycush			4.0 (T2A)			
	Ictalurus punctatus			6.8 (T1A)			
	Lepomis macrochirus			8.0 (T2A)			
Co-ral (97.5% active in acetone)	*Hexagenia* sp	BSA	–	0.43 (T1A)	a e	Dissolved oxygen was measured before and after assay. Assays were conducted in Mississippi River water.	Carlson (1966)
	Hydropsyche sp (larva)			0.005 (T1A)			
	Bluegill			1.4 (T1A)			

Cube powder (7.3% rotenone)	*Cyprinus carpio*	BSA	–	0.115 (L3)	a c d e i	Such variables as temperature, species, and size of fish were studied. Toxicity is expressed as LD_{50} for 72 hr. Smaller concentrations of rotenone were required when used in conjunction with sulfoxide. The data shown are for 70 F. The chemical was considerably more toxic at this temperature.than at 40 F for all fish species.	Hester (1959)
	Micropterus salmoides			0.164 (L3)			
	Pimephales promelas			0.200 (L3)			
	Carassius auratus			0.218 (L3)			
	Lepomis macrochirus			0.268 (L3)			
	L. cyanellus			0.246 (L3)			
	Notemigonus crysoleucas			0.620 (L3)			
	Ictalurus nebulosus marmoratus			0.346 (L3)			
Cube root	*Pimephales promelas*	BSA	–	0.066 (T4A)	a c d f g	Test water was spring water diluted with distilled water. Removal of toxic chemicals by carbon adsorption, chlorine and chlorine dioxide treatment, and alum coagulation was studied. The most effective method to remove fish poisons was by use of activated charcoal adsorption.	Cohen, et al (1961)
Cumate	*Pimephales promelas*	BSA	–	0.071 (T4A)	a c d e f	The toxicity of this substance was influenced by the quality of the water (pH, hardness, alkalinity). The chemical was more toxic in soft water.	Pickering and Henderson (1966)
	Lepomis macrochirus			0.32 (T4A)			
Cuprose	*Chlorella pyrenoidosa*	L	–	20 (AS 1)	–	Describes a bioassay method to differentiate between an algicide (AC) and an algistat (AS). The treated culture was subcultured as time progressed. Allen's medium was used.	Fitzgerald and Faust (1963)
2, 4-D	Killifish (minnow)	BSA	–	2000 (O)	a e	Temperature was held at 20-25 C, and the water was aerated by circulating water pumps. Data reported as deaths in 7 days. Upper safe limit concentrations were established.	Harrison and Rees (1946)
	Eupomotis gibbosus			1000 (O)			
	Ameiurus nebulosus			2000 (O)			
2, 4-D	*Eichornia crassipes*	FR	Fla.	(O)	–	Control of water hyacinth was affected with 1:1140 dilution applied to 100-150 sq ft plots. Author notes that no adverse effects to the water fauna (fingerling fish, etc.) were observed up to the time of disappearance of the water hyacinth. The roots were not killed, but did not readily produce shoots. Addition of carbowax as a wetting atent did not improve herbicidal action.	Hildebrand (1946)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
2,4-D	*Eichhornia crassipes* *Alternanthera philoxeroides*	FRLO	Mississippi R., Delta, La.	(O)	–	2,4-D was applied over weed-infested areas of the following types: borrow pits, drainage ditches, a shallow lake, a small tributary of the Mississippi River, and land areas. Water hyacinth was killed and sank under any condition in which it grows in South Louisiana by application of 8 lb/acre (free acid equivalent) of the amine salt of 2,4-D. A single application of 2,4-D at 8 lb/acre did not give complete elimination of alligator weed from borrow pits and deep ditches but it did reduce the population considerably.	Eggler (1953)
2,4-D	*Cylindrospermum licheniforme (Cl* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – PT (3) Ma – NT So – NT Cv – NT Gp – NT Np – T (3)	Palmer and Maloney (1955)
2,4-D	*Salmo gairdnerii*	BSA	–	2300 (T1A) 2050 (T2A)	a e	Most of the weed-killer formulations in this study consisted of more than one substance, i.e., oils, emulsifiers, stabilizers, and other adjuvants.	Alabaster (1956)
2,4-D	*Salmo gairdnerii*	BSA	–	4.4 (T1A) 3.3 (T2A)	a e	Comment same as above.	Alabaster (1956)
2,4-D	*Salmo gairdnerii*	BSA	–	3.0 (T1A) 2.2 (T2A)	a e	Comment same as above.	Alabaster (1956)
2,4-D	*Lepomis macrochirus* *Micropterus salmoides*	BSA	–	375 (T2A) 350 (T2A)	a c o	The response of bluegill and bass fingerlings to nine agricultural chemicals as determined by bioassay using river water is presented in this report. Bluegills were more tolerant of the chemicals tested than bass.	Davis and Hardcastle (1959)
2,4-D (granular)	*Nymphaea sp* *Myriophyllum brasiliense* *Myriophyllum heterphyllum* *Brasenia schreberi* *Utricularia sp*	FL	Farm ponds in Ga.	(O)	–	Granular 2,4-D controlled *Nymphaea sp., Myriophyllum heterphyllum, Brasenia schreberi,* and *Utricularia sp.* at the rate of 100 lb/acre (20 lb acid).	Thomaston, et al (1959)
2,4-D/ 2,4-5T + TCA	*Althernanthera philoxeroides*	FL	Fla.	(O)	–	At 19.2 pounds per acre, only 1-2 percent control of alligator weed was obtained.	Copeland and Woods (1959)

2,4-D/ 2,4-5T	*Althernanthera philoxeroides* *Typha / latifolia* Spatterdock	FL	Fla.	(O)	–	The degree of control was as follows: *A. philoxeroides* (5.0 lb/acre) – 1-2 percent *T. latifolia* (10.0 lb/acre) – 80 percent Spatterdock (5.0 lb/acre) – 5 percent	Copeland and Woods (1959)
2,4-D (pellets)	*Najas quadalupensis* Spatterdock	FL	Fla.	(O)	–	At 80.0 and 43.6 lb/acre, only 2 percent control of both species was obtained.	Copeland and Woods (1959)
2,4-D + TCA	*Panicum hemitomum*	FL	Fla.	(O)	–	At 90.0 lb/acre, 75 percent control of *P. hemitomum* was obtained.	Copeland and Woods (1959)
2,4-D (ester)	*Althernanthera philoxeroides* *Pontederia cordata* Spatterdock	FL	Fla.	(O)	–	At 4.2 lb/acre, the degree of control was as follows: *A. philoxeroides* – 2 percent *P. cordata* – 85 percent Spatterdock – 3 percent	Copeland and Woods (1959)
2,4-D (pellets)	Bushy pondweed	FL	Lakes in Fla.	(O)	–	Concentrations of 1.5 to 2.5 ppm controlled the bushy pondweed.	Phillippy (1961)
2,4-D (butoxyethanol ester)	*Lepomis macrochirus*	BSA	–	2.1 (T2A)	a e	The various salts of the chemicals showed wide variations in toxicity.	Hughes and Davis (1963)
2,4-D (acid, with emulsifiers)	*Lepomis macrochirus*	BSA	–	8.0 (T2A)	a e	Comment same as above.	Hughes and Davis (1963)
2,4-D (isopropyl ester)	*Lepomis macrochirus*	BSA	–	0.8 (T2A)	a e	Comment same as above.	Hughes and Davis (1963)
2,4-D (propylene glycol butylether ester)	*Lepomis macrochirus*	BSA	–	2.1 (T2A)	a e	Comment same as above.	Hughes and Davis (1963)
2,4-D (ethylester)	*Lepomis macrochirus*	BSA	–	1.4 (T2A)	a e	Comment same as above.	Hughes and Davis (1963)
2,4-D (di-n,n-dimethyl-cocoamine ester)	*Lepomis macrochirus*	BSA	–	1.5 (T2A)	a e	The various salts of the chemicals showed wide variations in toxicity.	Hughes and Davis (1963)
2,4-D (isooctyl ester)	*Lepomis macrochirus*	BSA	–	36 (T2A)	a e	Comment same as above.	Hughes and Davis (1963)
2,4-D (mixed butyl and isopropyl esters)	*Lepomis macrochirus*	BSA	–	1.5 (T2A)	a e	Comment same as above.	Hughes and Davis (1963)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
2,4-D (dimethylamine ester)	*Lepomis macrochirus*	BSA	–	416 (T2A)	a e	The various salts of the chemicals showed wide variations in toxicity.	Hughes and Davis (1963)
2,4-D (alkanolamine, ethanol and isopropanol series)	*Lepomis macrochirus*	BSA	–	580 (T2A)	a e	Comment same as above.	Hughes and Davis (1963)
2,4-D (oleic -1,3-propylene diamine)	*Lepomis macrochirus*	BSA	–	4.0 (T1A)	–	The bioassay methods employed in this experiment were not given in the paper but it was stated that the same procedures were employed as in previous work.	Davis and Hughes (1963)
2,4-D (butyl ester, oil soluble)	*Lepomis macrochirus*	BSA	–	4.9 (T1A)	–	Comment same as above.	Davis and Hughes (1963)
2,4-D (butyl ester)	*Lepomis macrochirus*	BSA	–	10 (T1A)	–	Comment same as above.	Davis and Hughes (1963)
2,4-D (butyl ester)	*Lepomis macrochirus*	BSA	–	1.3 (T2A)	a e	The various salts of the chemicals showed wide variations in toxicity.	Davis and Hughes (1963)
2,4-D (acid)	*Crassostrea virginica*	BCFA & BSA	–	2.0 (NTE)	–	Sea water was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
	Penaeus aztecus			2.0 (K10%)			
	Leiostomus xanthurus			50 (NTE)			
	Phytoplankton			–			
2,4-D (propylene glycol butyl ether ester)	*Crassostrea virginica*	BCFA & BSA	–	1.0 (0,39%)	–	Comment same as above.	Butler (1965)
	Penaeus duorarum			1.0 (NTE)			
	Leiostomus xanthurus			4.5 (T4A)			
	Fundulus similis						
	Mugil cephalus						
	Cyprinodon variegatus						
	Phytoplankton			44% (O)			

2,4-D (2-ethyl hexyl ester)	*Crassostrea virginica* *Penaeus aztecus* *Mugil cephalus cephalus* Phytoplankton	BCFA & BSA	–	5.0 (0,38%) 2.0 (0,10%) 10 (NTE) 49% (O)	–	Comment same as above.	Butler (1965)
2,4-D (iso-octyl ester)	*Lepomis macrochirus*	BSA	–	(L) 8.8-59.7 (T2A) (G) 116-1000 (T2A)	a c d e g	Toxicity data for 24 and 48 hours are presented for liquid (L) and granular (G) formulations. Various commercial formulations were tested. The liquid formulations were almost invariably more toxic than the granular ones.	Hughes and Davis (1965)
2,4-D (propylene glycol butyl ether ester)	*Lepomis macrochirus*	BSA	–	(L) 2.1 (T2A) (G) 9.3 (T2A)	a c d e g	Comment same as above.	Hughes and Davis (1965)
2,4-D (butoxy ethanol ester)	*Lepomis macrochirus*	BSA	–	(L) 2.1 (T2A) (G) 34.5 (T2A)	a c d e g	Comment same as above.	Hughes and Davis (1965)
2,4-D (butoxy ethanol ester)	*Crassostrea virginica* *Penaeus duorarum* *Fundulus similis* Phytoplankton	BCFA & BSA	–	3.75 (O) 1.0 (NTE) 5.0 (T2A) 16% (O)	–	Sea water was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
2,4-D (dimethyl-amino salt)	*Crassostrea virginica* *Penaeus aztecus* *Fundulus similis* Phytoplankton	BCFA & BSA	–	2.0 (NTE) 2.0 (0,10%) 15 (T2A) –	–	Comment same as above.	Butler (1965)
2,4-D (butoxy ethanol ester)	*Crassostrea virginica* *Pleurobena cordatum*	BCFA & BSA	–	2.0 (O) 5.0 (NTE)	–	Comment same as above.	Butler (1965)
2,4-D	*Daphnia magna*	BSA	–	>100 (O)	a c d i q	Toxicity, in terms of median immobilization concentration (IC_{50}), is presented.	Crosby and Tucker (1966)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
2,4-D	*Salmo gairdneri*	BSA	–	1.1 (T2A)	a	This paper reports acute toxicity of a number of compounds, and discusses sub-acute mortality as well. Effects on reproduction and behavior are also discussed. Data presented as EC_{50}.	Cope (1966)
	Lepomis macrochirus			0.9 (T2A)			
	Pteronarcys californica			1.8 (T2A)			
	Daphnia pulex			3.2 (T2A)			
	Simocephalus serrulatus			4.9 (T2A)			
2,4-D	*Lepomis macrochirus* *Elliptis crassidens*	FO	Tenn. and Ala.	(O)	–	There was little uptake of 2,4-D (treatment was with a 20% granular material at the rate of 100 lb. of 2,4-D acid equivalent per acre) by fish but some by mussels.	Smith and Isom (1967)
2,4-D (dimethylamine)	*Lepomis macrochirus*	BSA	–	188 (T1A)	a b e	This report is a simple and straightforward determination of a median tolerable limit for a selected group of herbicides.	Hughes and Davis (1967)
2,4-D (isooctylester)	*Lepomis macrochirus*	BSA	–	453 (T1A)	a b e	Comment same as above.	Hughes and Davis (1967)
2,4-D (butoxy-ethanol ester)	*Pimephales promelas*	BCFCH	–	0.2-1.5 (O)	a c d e q	Carbon-filtered tap water was used as diluent. Growth and reproduction were not affected by 2,4-D at range of concentrations indicated. No mortalities occurred.	Mount and Stephan (1967)
2,4-D (esters)	*Lepomis macrochirus* (eggs)	L	–	50 (S), 10 (NTE), 5.0 (NTE)	–	Fertilized fish eggs of indicated species were placed in 1 liter of test solution and allowed to hatch. Toxicity data are presented as concentration in ppm/number of days survival. Maximum length of test was 8 days. No food was added. Small bluegill were tested to find the highest concentration of chemical which did not cause death in 12 days (S).	Hiltibran (1967)
	L. cyanellus (eggs)			10/4 (O)			
	Micropterus dolomieui (eggs)			10/5 (O)			
	Erimyzon sucetta			5.0 (NTE)			
	L. macrochirus (fry)			50 (S)			
2,4-D (dimethyl-amine salt)	*Lepomis macrochirus* (eggs)	L	–	25 (NTE)	–	Comment same as above.	Hiltibran (1967)
	L. cyanellus (eggs)			25 (NTE)			
	Micropterus dolomieui (eggs)			25 (NTE)			
	Erimyzon sucetta (eggs)			25 (NTE)			
	L. macrochirus (fry)			40 (S)			

2,4-D (butoxy-ethanol ester)	*Pimephales promelas*	BSA & CH	–	5.6 (T4A)	a c d e f	The fish could tolerate 1/19 this amount of 2,4-D for a ten-month test.	Mount and Stephan (1967)
2,4-D (Na salt)	*Lepcmis macrochirus* (fry)	L	–	100 (S)	–	Fertilized fish eggs of indicated species were placed in 1 liter of test solution and allowed to hatch. Toxicity data are presented as concentration in ppm/number of days survival. Maximum length of test was 8 days. No food was added. Small bluegill were tested to find the highest concentration of chemical which did not cause death in 12 days (S).	Hiltibran (1967)
2,4-D (esters)	*Lepomis macrochirus* (eggs)	L	–	4/2 (O)	–	Comment same as above.	Hiltibran (1937)
	L. cyanellus (eggs			4.0 (NTE)			
	Micropterus dolomieui (eggs)			4.0 (NTE)			
	L. macrochirus (fry)			3.0 (S)			
2,4-D	*Lepomis macrochirus* (eggs)	L	–	5/1 (O)	–	Comment same as above.	Hiltibran (1967)
2,4-D	Rainbow trout	BSA	–	1.1 (T2A)	–	Data are given as LC_{50}.	Bohmont (1967)
	Bluegill			3.7 (T2A)			
2,4-D (PGBE ester)	*Lepomis macrochirus* (eggs)	L	–	1/2 (O)	–	Fertilized fish eggs of indicated species were placed in 1 liter of test solution and allowed to hatch. Toxicity data are presented as concentration in ppm/number of days survival. Maximum length of test was 8 days. No food was added. Small bluegill were tested to find the highest concentration of chemical which did not cause death in 12 days (S).	Hiltibran (1967)
	L. cyanellus (eggs)			1/5 (O)			
	Micropterus dolomieui (eggs)			1/5 (O)			
	Erimyzon sucetta (eggs)			1/5 (O)			
	L. macrochirus (fry)			2 (S)			
2,4-D (butoxy-ethanol ester)	*Anopheles quadri-maculatus* (4th instar)	BSA	–	(O)	–	The Watts Bar test site was treated with a 20% granular material at the rate of 100 lb of 2,4-D acid equivalent per acre. The Guntersville area was treated at the rate of 40 lb per acre. The applications were made for control of Eurasian watermilfoil, *Myriophyllum spicatum*. The toxic effect of 2,4-D was evaluated by sampling the benthic invertebrate communities of both reservoirs before treatment and at least twice after treatment. Residue analysis of water, fish, plants, mussels, and sediment were used to study diffusion, accumulation, translocation, and/or degradation of 2,4-D. In both areas at both concentrations, a monitoring device showed some movement of lake fish out of the treated area, but no mortality of fish occurred. A total of 50 assorted frozen samples of plants, animal tissue, and mud were analyzed for 2,4-D. Application of 2,4-D at the given concentrations caused no measurable toxic effect on benthic fauna.	Smith and Isom (1967)
	Lepomis macrochirus *Elliptis crassidens* *Hexagenia* *Tendipedidae* *Heleidae* *Chaoborus* *Oligochaeta* *Corbicula* and others	FS	Watts Bar Reservoir T.V.A. Guntersville Reservoir T.V.A.				

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
2,4-D	*Pteronarcys californica* (naiads)	BSA	–	0.015 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
2,4-D (butoxy ethanol ester)	*Pteronarcys californica* (naiads)	BSA	–	0.0016 (T4A)	a c d e f	Comment same as above.	Sanders and Cope (1968)
2,4-DA (pellets)	Water lettuce	FL	Lakes in Fla.	(O)	–	An application rate of 10 lb/acre controlled water lettuce.	Phillippy (1961)
DAC, dodecylacetamido dimethyl benzyl ammonium chloride	*Pimephales promelas*	BSA	–	0.65 (T4A)	a c d e f	Toxicity to 30 species of algae also presented. DAC was algicidal in the range 0.25 to 2.0 ppm.	Maloney and Palmer (1956)
Dacthal	*Lepomis macrochirus*	BSA	–	1000 (T1A)	a b e	This report is a simple and straightforward determination of a median tolerance limit for a selected group of herbicides.	Hughes and Davis (1967)
Dacthal	*Crassostrea virginica* *Penaeus aztecus* *Cyprinodon variegatus* Phytoplankton	BCFA & BSA	–	0.25 (O) 1.0 (NTE) 1.0 (NTE) 37% (O)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
Dalapon (sodium salt)	*Fundulus similis* (juvenile)	BSA	–	(O)	a	Water temperature was 20 C. No effect was noticed on exposure to 1.0 ppm.	Butler (1965)
	Oyster	BCF				No effect on exposure to the chemical at 1.0 ppm.	
	Penaeus aztecus	L				Toxicant chemicals were evaluated in seawater at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality. A concentration of 1.0 ppm caused 30 percent mortality.	

Dalapon (sodium salt)	*Crassostrea virginica* *Penaeus aztecus* *Fundulus similis* Phytoplankton	BCFA & BSA	–	1.0 (NTE) 1.0 (0,40%) 1.0 (NTE) (O)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
Dalapon (sodium salt)	*Pteronarcys* sp (nymphs)	BSA	–	>1000 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Dalapon (Na salt)	*Pteronarcys californica* (naiads)	BSA	–	100 (NTE)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Dalapon	Cattails and other aquatic plants	FL	Farm ponds in Ga.	(O)	–	Dalapon was used primarily to control marginal grasses and cattails. Cattails can be eradicated at the rate of 1 lb to 5 gal of water or 20 lb/acre. It was indicated that 1 lb to 7.5 gal (15 lb per acre) proved satisfactory for control of cattails.	Thomaston, et al (1959)
Dalapon (Radapon)	*Lepomis macrochirus* *Pimephales promelas*	BSA	–	(S) 440 (T4A) (S) 390 (T4A) (H) 290 (T4A)	a c e	Bioassay method in Standard Methods for Examination of Water was used. Both hard (H) and soft (S) water were used. TL_m values for 24 and 48 hr are also presented.	Surber and Pickering (1962)
Dalapon (tech)	Bluegill	BSA	–	105 (T4A)	a	This is an estimated LC_{50} value at temperatures from 55 to 75 F.	Cope (1965)
Dalapon	*Simocephalus serrulatus* *Daphnia pulex*	BSA	–	16 (SB) 11 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
Dalapon	*Lepomis macrochirus* (eggs) *L. cyanellus* (eggs) *Micropterus dolomieui* (eggs) *Erimyzon sucetta* (eggs) *L. macrochirus* (fry)	L	–	50 (S), 50 (NTE) 50 (NTE) 50 (NTE) 50 (NTE) 50 (S)	–	Fertilized fish eggs of indicated species were placed in 1 liter of test solution and allowed to hatch. Toxicity data are presented as concentration in ppm/number of days survival. Maximum length of test was 8 days. No food was added. Small bluegill were tested to find the highest concentration of chemical which did not cause death in 12 days.	Hiltibran (1967)
Dalapon	Salmon Bluegill	BSA	–	340 (T2A) 115 (T2A)	–	Data are given as LC_{50}.	Bohmont (1967)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
4-(2,4-DB)	*Lepomis macrochirus*	BSA	–	8.0 (T2A)	a c o	The response of bluegill and bass fingerlings to nine agricultural chemicals as determined by bioassay using river water is presented in this report. Bluegills were more tolerant of the chemicals tested than bass.	Davis and Hardcastle (1959)
	Micropterus salmoides			10 (T2A)			
4 (2,4) DB, (tech)	Rainbow trout	BSA	–	5.4 (T4A)	a	This is an estimated LC_{50} value at temperatures from 55 to 75 F.	Cope (1965)
DBrDT (DDT analogue)	Goldfish	BSA	–	0.06 (K)	–	Experiments were run a maximum of 3 days. No other time data were reported.	Odum and Sumerford (1946)
	Gambusia affinis			0.01 (K)			
	Culex apicalis (larvae)			0.0015 (K)			
DBS	Trout	BCHA	–	5.0-20 (SB)	–	Fish exposed to 5.0 ppm of the chemical suffered a reduction of the epithelium and a loss of mucous cells on top of the gill laminae. Exposure to 20 ppm for one hour caused great destruction of the epithelium – followed by death from suffocation.	Schmid and Mann (1961)
DDD	Channel catfish (fingerlings)	BSA	–	<2.6 (K 25 hr A)	a	Tap water was used. Conserable additional data are presented.	Clemens and Sneed (1959)
DDD	White catfish Largemouth bass Brown bullhead Black crappie Bluegill Hitch Sacramento blackfish Carp	FLCH	Cal.	0.014 (SB, application rate for 1949, -51, -57)	a g	Gnat control program with follow-up on accumulation in various species of wildlife. Ppm of DDD in edible flesh white catfish in 1958 was 30.4-129.0, Concentrations in remaining fish were 5.4-115 ppm.	Hunt and Bischoff (1960)
DDD (TDE, tech)	*Salmo gairdneri*	BSA	–	30 (T1A)	a	The experiment was conducted at 55 F. Fish were 2-3 in. long.	Cope (1963)

TDE (DDD)	*Chironomus riparius* *Asellus aquaticus* *Salmo gairdnerii*	FL	Essendon Hertfordshire	(O)	a c m	Initial laboratory tests suggested that settleable powder formulations of TDE and DDT at application rates greater than 0.5 lb/acre would be effective in controlling *Chironomus* larvae, and that while trout would not be killed either directly (0.5-1 lb/acre) or by feeding on TDE-treated larvae, other invertebrates, e.g. *Asellus*, would be affected. Tubificids were not killed at application rates up to 2 lb/acre. TDE was considered a more useful insecticide than DDT because of its lower toxicity to fish. Carp were kept in cages for 11 months following the insecticide treatment; 35% died but the survivors grew well. By November 1962, fish tissues contained about 15 ppm TDE. In lab studies a 50 percent kill occurred in 7 days, at 0.1 lb per acre for chironimid larvae, at 0.5 lb per acre for *A. aquaticus*, and 2 lb per acre killed 10% of the tubificid worms. No deaths of rainbow trout occurred in 7 days at 2 lb per acre.	Edwards, et al (1964)
DDD	*Gambusia affinis affinis*	BSA	–	0.46 to (L 1-1/2)	a	The lower value is for fish that had never been exposed to the toxicant, and the higher value was obtained with fish that had been exposed to a sublethal dose in the past. Apparently such an exposure produces a resistance that can be retained when they are exposed later.	Boyd and Ferguson (1964)
DDD (tech)	Bluegill	BSA	–	0.042 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
DDD	*Pygosciles adeloriae* *Lobodon carcinophagus*	FM	Ross Island, Antarctic	(O)	a	Adult penguins assayed showed no residue. The pre-molts examined had residues ranging from 0 to 16 ppb in the liver and 0 to 2 ppb in the fat. The crabeater seal examined showed residues of 2 ppb in the liver and 7 ppb in the fat.	George and Frear (1966)
TDE (DDD)	*Simocephalus serrulatus* *Daphnia pulex*	BSA	–	0.0045 (SB) 0.0032 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 48 hr. Data cited are for 60 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
pp'DDD	*Buteo buteo* *Accipiter gentilis* *Accipiter nisus* *Falco tinnunculus* *Tyto alba* *Strix aluco*	FO	Netherlands	(O)	–	The results of this study show that birds of prey and fish-eating birds found dead in the Netherlands accumulated large amounts of different chlorinated hydrocarbon insecticides. In most cases the liver had the highest concentration of toxicant, ranging from 0.08 to 8.6 ppm. Most chlorinated hydrocarbons tend to accumulate in the fat depots of the body. In instances where mesenterial fat was analyzed the concentration of toxicant was found to be as high as 5.1 ppm.	Koeman and van Genderen (1966)

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Chemical	Organism	Bicassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
TDE (DDD)	*Daphnia magna*	BSA	–	0.0046 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
DDD	Atlantic salmon Brook trout	FR	New Brunswick	(O)	–	Spraying with this chemical at 0.25 to 0.5 lb/acre was no more harmful than with DDT at 0.25 lb/acre.	Kerswill and Edwards (1967)
DDD	*Limnephilus rhombicus* *Sialis* sp *Gammarus* sp	–	Knights Creek, Wisc.	(O)	–	Pesticide usage in an orchard did not significantly contaminate the aquatic environment of this creek adjacent to the treatment as determined by residue analysis.	Moubry, et al (1968)
TDE (DDD)	*Pteronarcys californica* (naiads)	BSA	–	0.38 (T4A)	a c d e f	Data reported at LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968
DDE	*Penaeus aztecus*	L	–	0.0068 (O)	a	Toxicant chemicals were evaluated in sea water at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality.	Butler (1965)
DDE	Oyster	BCF	–	0.014 (O)	a	The value reported is a 96-hr EC_{50} (decreased shell growth).	Butler (1965)
DDE	*Leptonychotes weddelli* *Pygosalis adeloriae* *Catharacta skua maccormicki*	FM	Antarctic	(O)	a	All residues are expressed as ppm wet weight. It was established that residues in the water were less than 0.0005 ppm. No detectible residues were found in tissues of *L. weddelli.* No detectable residues were found in tissues of *P. adelias.* Residues ranging from 0.01 to 0.73 ppm were found in tissues of *C. skua maccormicki.*	George and Frear (1966)
DDE	*Pygosciles adeloriae* *Lobodon carcinophagus*	FM	Ross Island, Antarctic	(O)	a	Adult penguins assayed had residues ranging from 20 to 28 ppb in the liver. The fat residues in the pre-molts penguins ranged from 19 to 45 ppb. Crabeater seal examined showed residues of 7 ppb in the liver and 17 ppb in the fat.	George and Frear (1966)
pp'DDE	*Platalea leucorodia* *Haematopus ostralegus* *Sterna sandvicensis* *Sterna hirundo* *Larus ridibundus* *Somateria mollissima* *Tadorna tadorna*	FO	Netherlands	(O)	–	The results of this study show that birds of prey and fish-eating birds found dead in the Netherlands accumulated large amounts of different chlorinated hydrocarbon insecticides. In most cases the liver had the highest concentration of toxicant, ranging from 0.1 to 6.0 ppm. Birds feeding predominantly on crustacea, molluscs, and fish contained significant amounts.	Koeman and van Genderen (1966)

pp'DDE	*Buteo buteo* *Accipiter gentilis* *Accipiter nisus* *Falco tinnunculus* *Tyto alba* *Strix aluco* *Osio otus* *Falco pereginus*	FO	Netherlands	(O)	–	The results of this study show that birds of prey and fish-eating birds found dead in the Netherlands accumulated large amounts of different chlorinated hydrocarbon insecticides. In most cases the liver had the highest concentration of toxicant, ranging from 1.2 to 75.2 ppm. Most chlorinated hydrocarbons tend to accumulate in the fat depots of the body. In instances where mesenterial fat was analyzed the concentration of toxicant was found to be as high as 68.3 ppm.	Koeman and van Genderen (1966)
pp'DDE	*Esox lucius*	FR	River Nene, Eng.	(O)	–	Higher concentrations were found in larger fish, indicating that they had been exposed to the pesticides for a longer time. Tissue extracts from the pike were analyzed for organochlorine pesticide residues by gas liquid chromatography. The average of six determinations was: 0.72 ppm muscle 96.0 ppm fat	Mawdesley-Thomas and Leahy (1967)
op'DDE	*Esox lucius*	FR	River Nene, Eng.	(O)	–	Comment same as above except that values for large fish only were: 0.042 ppm muscle 6.6 ppm fat	Mawdesley-Thomas and Leahy (1967)
DDE	*Limnephilus rhombicus* *Sialis* sp *Gammarus* sp	–	Knights Creek, Wisc.	(O)	–	Pesticide usage in an orchard did not significantly contaminate the aquatic environment of this creek adjacent to the treatment as determined by residue analysis.	Moubry, et al (1968)
DDE	Oyster	FE	Galveston Bay, Texas	(O)	–	The chemical was found in the water at a concentration of $<$0.001 ppm. Oysters from the area were found to contain $<$0.01 to 0.05 ppm.	Casper (1967)
DDE	Vascular plants Algae Chubs Largemouth bass Clams	FL	Tule Lake, Ore.	(O)	–	The amount of chemical sprayed in this area was not specified. The residue found was in the range of 0.6 to 1.0 ppb. Residue in chubs was from 2.5 to 45.0 ppb. The bass contained 11.0 to 38.0 ppb. Clams contained 0.75 to 6.3 ppb. The water contained 0.003 to 0.027 ppb.	Godsil and Johnson (1968)
DDE	*Alosa pseudoharengus* *Aplodinotus grunniens* *Coregonus artedii* *Lota lota*	BSA	–	(O)	–	The study showed that the levels of chlorinated hydrocarbon pesticide residues in the fish meals and oils were, with the exception of the oil sample taken from the Lake Michigan alewife, below the regulatory tolerances established by the Food and Drug Directorate of Canada (1965) for certain foods intended for human consumption. Pesticide levels were interpreted as being representative for each species.	Dugal (1968)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
DDE	*Potamogeton pectinatus* *Cladophora* *Oscillatoria* *Cynodon dactylon* *Arundo donax*	FR	Arizona	(O)	–	Irrigation canals were examined for plants which might serve as DDT collectors or indicators of DDT usage by concentrating this material and its metabolites. Highest residues were found in *Cladophora* (19 ppm), followed by *Potamogeton* (9 ppm), and finally *Oscillatoria* (5 ppm).	Ware, et al (1968)
DDT	*Carassius auratus*	BSA	–	(O)	–	DDT was used in 2 forms, as a dust containing 5 percent of DDT and in acetone solutions as a water suspension. The dusts were applied to the surface of the water by sifting through a fine-mesh screen. DDT produced characteristic symptoms in the goldfish in 24 hours when applied as either of the above formulations at concentrations of 0.2-2.0 ppm, but not at lower concentrations. The nervous system was affected causing a loss of equilibrium. When *physa* sp were tested, only the DDT from acetone solution was employed.	Eide, et al (1945)
DDT	*Huro salmoides* *Lepomis macrochirus* *Notemigonus crysoleucas* *Carassius auratus*	FR	Back Creek, Glengary, W. Va.	(O)	d	Aerial application of 1 pound per acre was made by plane. Only 0.39 pounds of DDT per acre reached the stream surface. Open live-boxes of fish were placed above, below, and within the sprayed section at five points. Of the 452 fish in these boxes, only 5 died from toxicity of the DDT. Predators removed a considerable number of fish from one live-box, and the handling of the fish was responsible for other losses. However, the survival, even with these losses, amount to 89.8%.	Hoffman and Surber (1945)
	Invertebrates Orders: Annelida Megaloptera Ephemeroptera Odonata Plecoptera Coleoptera Trichoptera Diptera Mollusca					Application of the chemical showed a rapid paralyzing effect on invertebrates. Application upon the bottom fauna revealed good survival (67%) at the first station and poorer survival (26% and 33%) at locations down stream. Wettable DDT applied at 1 pound per acre is not so toxic to fish and fish-food organisms as the same amount of DDT applied in an oil spray.	
DDT	*Daphnia magna*	BSA	–	0.001 (SB1A)	–	Sublethal effect observed was immobilization of the *Daphnia*. Lake Erie water was used.	Anderson (1945)
DDT	*Carassius auratus*	BSA	–	2.0 (K1) 1.0 (O)	e	Ethyl alcohol was used as a solvent for 2 percent DDT. At 1 ppm, 90 percent of the fish were killed in 1 day.	Ginsburg (1945)

DDT (mosquito larvicide 50-D)	*Carassius auratus*	BSA	–	0.4 (O)	e	Mosquito Larvacide 50-D is water-white kerosene containing 3 percent DDT in solution and emulsified with sodium lauryl sulfate. A concentration of 0.4 ppm caused a mortality of 30 percent in 3 days at the spraying rate of 0.42 pounds per acre.	Ginsbury (1945)
DDT (Dust)	*Carassius auratus*	BSA	–	0.1 (O)	e	A concentration of 0.1 ppm killed 17 percent of the fish in 3 days at a spraying rate of 0.1 pounds per acre. 1.0 ppm killed 17 percent of the fish in 3 days at a spraying rate of 1.0 pounds per acre.	Ginsburg (1945)
DDT	*Salmo trutta*	BSA	Ithaca, N.Y.	0.25 (T1A)	a	LD_{50} was determined in hours of survival time. The chemical was added as a wettable powder, as a solution in xylene with an emulsifying agent, and as a kerosene solution. It was most toxic as the emulsion.	Everhart and Hassler (1945)
DDT	Fall fish Common shiner Bluegill sunfish Eastern madtom Silverling minnow	FRK	Patuxent River, Md.	(O)	–	Fish kill occurred after an area was sprayed with an oil solution of DDT at the rate of 2.0 lb/acre. Several other field studies were discussed in this report, but without much quantitative data. It is interesting that this paper presented as the first recommendation "Don't use DDT unless you must."	Cottam and Higgins (1946)
DDT		FR	W. Va.	(O)	–	An oil preparation of DDT was applied from a plane. The average deposit was 0.27 pounds per acre even though it was applied at 1 pound per acre. Thirteen stations were set up for sampling, Nrs. 1 and 2 were above point of application and the remainder were at and below the application point up to 2.0 miles. In general the closer the station to the point of application the more toxic the chemical.	Surber and Friddle (1946)
	Hyborhynchus notatus			1.0 (O)		Bluntnose minnows were not affected by the spray.	
	Micropterus salmoides			1.0 (O)		Greatest toxicity was noted at Station 10 (0.8 miles from point of application) which showed 46% survival. 100% survival occurred at Station 13 (2 miles from point of application).	
	Lepomis macrochirus			1.0 (O)		Greatest toxicity was noted at Station 10 (0.8 miles from point of application) which showed 74% survival. All other stations except 13, which had 100% survival, showed 92% survival of bluegill.	
	Pimephales promelas					Blackhead minnows showed 68-74% survival at most stations; 100% at Station 13. DDT proved to be more toxic when applied as an oil spray rather than a suspension or a powder.	

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
DDT	Goldfish	BSA	—	0.07 (K)	—	Data are also given for analogues of DDT. Experiments were run a maximum of 3 days. No other time data were reported.	Odum and Sumerford (1946)
	Goldfish plus *Elodea* spp and *Cabomba* spp			0.16 (K)			
	Gambusia affinis			0.1 (K<1)			
	Culex apicalis (larvae)			<0.0001 (K)			
	Culex apicalis (pupae)			0.025 (K)			
DDT	*Carassius auratus*	BSA	—	0.2 (K5)	—	DDT fed to mosquito larvae at 1 part per 20 million killed 100 percent of the mosquitos in 2 days. DDT fed to goldfish at 1 part per 5 million killed 100 percent of the goldfish in 5 days. Mosquito larvae killed by DDT at the above concentration when fed to goldfish did not have a toxic effect.	Ginsburg (1947)
	Aedes aegypti			0.05 (K2)			
DDT (Velsicol NR-70)	Numerous fish species and other aquatic organisms	FL	Tenn.	(O)	—	DDT was applied by thermal aerosol at the rate of 0.1 lb/acre. Rate at center of swath was 0.012 lb/acre. Anopheline and culicine mosquitoes were almost eliminated. After 16 applications, the conclusion was that fish populations were unchanged when compared to controls.	Hess and Keener (1947)
DDT	*Mastigophora* Infusoria Hydrocarina Diatomaceae *Synura* Dinoflagellata *Phacus* Rototoria Copepoda Chroococcaceae Scenedesmaceae *Chlamydomonas* *Euglena* *Trachelomonas* *Sarcodina*	FL	Savannah, Ga.	(O)	—	No drastic killing of any specific group of organisms occurred from DDT treatment. At 0.5 lb/acre DDT spray, the growth of *Mastigophera, Synura,* Dinoflagellata, and Copepoda was inhibited; while *Phacus,* Rototaria, Chroococcaceae, and *Euglena,* appeared to be stimulated. All others were apparently unaffected. Similar results were obtained with a 0.1-0.2 lb/acre dust application of DDT. The author uses line-graphs to indicate trends of populations before and after treatment.	Bishop (1947)
DDT-copper sulfate	*Synedra* spp *Daphnia* spp *Cyclops* spp	FL	Del.	(O)	—	Describes conditions, after DDT aerial spraying of a city water reservoir. Zooplankton disappeared with an over abundance of *Synedra* spp. Control of *Synedra* spp with 0.25 ppm $CuSO_4$ was not effective. A possible antagonism of DDT to copper sulfate is noted.	Shane (1948)

DDT	Bluegill Largemouth black bass Smallmouth black bass Golden-shiner Black crappies	FL & CF	Kearneysville, W. Va.	(O)	a	Small bluegills, largemouth black bass, and smallmouth black bass one inch in length were killed by DDT in oil formulations in applications ranging from 0.25 to 1.0 pound per acre. Golden shiner fry were killed by oil sprays in excess of 0.25 pound per acre in dirt-bottomed ponds. Young black crappies 1.2 inches in length were killed by 0.5 pound per acre of DDT in both suspension and oil formulations. Fingerlings 2 inches or more in length were better able to withstand the higher rates of application. Fingerling bluegills, smallmouth black bass, and black crappies were found to be more sensitive to DDT than largemouth black bass, golden shiners, and trout. In continuous flow raceways, brook and rainbow trout, smallmouth bass, and golden shiners were relatively unaffected by a 1 pound per acre application of DDT.	Surber and Hoffman (1949)
DDT	Black fly (larvae) Rainbow trout Caddis fly	FR	Alaskan streams	0.3 (O)	–	The chemical was applied for control of black flies, and because the acetone solution was most effective, only that data is reported here. The figures reported are for minimum effective dosages for black fly larvae and maximum nonlethal dosages for rainbow trout and caddis fly larvae.	Gjulian, et al (1949)
DDT	*Lebistes reticulatus*	BSA	–	0.025 (K1-15%)	–	This is a bioassay method for determining DDT residue extracted from vegetables.	Pagan and Hageman (1950)
DDT	*Lepomis macrochirus*	FL	Auburn, Ala.	0.1 to 0.5 (K)	–	Adult fish were not killed at 0.2 ppm. All were killed at 0.5 ppm in earthen ponds, in concrete pools 0.04 ppm was lethal.	Lawrence (1950)
	Micropterus salmoides			–	--	Adult fish were killed at concentrations greater than 0.1 ppm.	
	Notemigonus crysoleucas auratus			–	–	This species withstood a concentration of 0.18 ppm.	
	Pomoxis nigromaculatus			–	–	In concrete pools. 0.18 ppm was lethal to this species.	
	Megastomatobus cybrinella			–	–	Withstood 1.0 ppm in earthen ponds.	
	Pimephalas promelas			–	–	The last two species withstood 0.4 ppm, but were killed at 2.0 ppm.	
	Carassius auratus			–	–	The toxicity of DDT to all species seems to be partly dependent on the form in which the chemical is added – as wettable powder or emulsion.	
DDT	Bottom organisms. Ephemeroptera Odonata Plecoptera Megaloptera Coleoptera Trichoptera Diptera	FR	Wilkes Barre, Pa.	(O)	–	The DDT application of 1 lb/acre was made for control of *Porthetria dispar*, gypsy moth. Aquatic insects of the orders Megaloptera and Odonata appeared to be resistant to DDT poisoning at the dosage applied. Trichoptera were affected severely. Insect mortality increased as DDT moved down stream.	Hoffman and Drooz (1953)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
DDT	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – NT Ma – T (7) So – NT Cv – NT Gp – PT (7) Np – NT	Palmer and Maloney (1955)
DDT	*Labea* sp *Synodontis schall*	FR	Khartoum	(O)	–	A section of the Blue Nile was sprayed by air with an emulsified oil containing 30% DDT and 0.5% "Lissapol". The material was applied about 10 miles above Khartoum. It was hoped that by the time the treated water reached Khartoum, the DDT concentration would have been diluted 4 times. The concentration at the time of arrival was 0.17 ppm, and was maintained at a level of 0.003 ppm for 6 hr. It was reported that hundreds of fish were found dying 2 miles above Khartoum. *Labea* sp died in 8 hr and *Synodontis schall* died in 31 hr. The fish were analyzed for DDT residue the next day. The results are given below: — Gills / Viscera / Flesh Fatty Deposit *Labea* sp: 0.9 ppm / 2.5 ppm / Nil *Synodontis schall*: 2.7 ppm / 7.9 ppm / 64 ppm	Burden (1956)
DDT	*Labea* sp *Synodontis schall*	F	Khartoum	0.09 (K)	–	Various levels of DDT were found in dead fish from 0.017 to 0.003 ppm downstream from the application. Undetermined degree of kill occurred.	Burdick, et al (1965)
DDT	Young salmon	F	Canada	(O)	–	No toxicity data on fish were reported. The report deals primarily with reduction of insects available as fish food.	Ide (1957)
DDT	*Salmo salar* *Salvelinus fontinalis* *Salmo gairdnerii*	BSA	–	0.08 (L3) 0.16 (L<1) 0.08 (L3) 0.16 (L<2) 0.08 (L3) 0.16 (L<2)	a e	100 percent mortality occurred at 0.16 ppm in 18 hours for landlocked salmon, in 54 hours for rainbow trout, and 26 hours for brook trout.	Hatch (1957)
DDT	*Simulium* sp (larvae)	FR	Streams, S. C. and Fla.	0.1-3.4 (O)	–	In slow-moving streams in Florida and South Carolina, DDT at the indicated concentrations controlled blackfly larvae for up to 0.28 mile. Control lasted for approximately 2 weeks. Data are presented as percent larval detachment in 1, 2, and 3 days time. Emulsion (0.1 ppm), oil (0.1 ppm), and granule (0.5-1.0 lb/acre) formulations had about the same degree of effectiveness.	Davis, et al (1957)

DDT	Blue crab Marsh fiddler crab Red-jointed fiddler crab *Cyprinodon variegatus* *Leiostomus xanthurus* *Mugil curema*	FE	Bombay Hook Island, Del.	(O)	–	The location under study was a salt marsh bounded by Delaware Bay. DDT was applied at 0.2 pound per acre. Organisms were confined in cages within the test area. *C. variegatus, M. curema,* and *L. xanthurus* showed no mortality when exposed for 7 days. Blue crabs showed 17 percent mortality when exposed for 7 days in streams and 10 percent mortality in ponds. Marsh fiddler crabs and red-jointed fiddler crabs showed 75 and 36 percent mortality, respectively, in 7 days.	George, et al (1957)
DDT	Insectivorous fish Ephemeroptera Trichoptera	FR	Uganda	(O)	–	Rapid recolonization of aquatic insect populations decreased the possibility of accumulation of DDT by fish. Application rate was not given.	Corbet (1958)
DDT	Various aquatic and terrestrial organisms	FL	Salt Lake Co., Utah	(O)	–	The chemical was applied at 0.3 lb/acre. This concentration was sufficient for mosquito larvae control. At the above concentration no ill effects were observed in mammals, birds, reptiles, and amphibians. Invertebrates were not affected uniformly. Crustaceans were not harmed, nor were larvae of the insect family Ephydridae. Spiders and aquatic insects other than Ephydridae were adversely affected in varying degrees. Aquatic beetles seemed to be affected more seriously than other insects except mosquito larvae.	Graham and Anderson (1958)
DDT	Atlantic salmon	BSA	–	0.049 (T1A) 0.047 (T2A)	a e	Results are recorded in ppm of insecticide by weight in water. Changes in temperature had an effect on the toxicity of the chemical.	Keenleyside (1958)
DDT	Brook, rainbow and cutthroat trout and whitefish Aquatic insects	FR	Montana	–	a c d	This study involves 13 rivers and streams following aerial spraying of DDT at rate of 1 lb/acre for control of spruce bud worm. The DDT recovery rate varied from 0.19-0.32 lb/acre. Significant amounts of DDT in fish tissue were found 16 months after spraying. The concentrations varied from 0.01 μg/mg to 4.0 μg/mg. Aquatic bottom invertebrates and adult insects were materially reduced in number but recovered in 1 year.	Graham and Scott (1958)
DDT	*Artemia salina*	BSA	–	0.142 (K<1)	a i	Rock salt was used in rearing all cultures employed in bioassay work. The optimum salt concentration was 3.5%.	Tarpley (1958)
DDT	Fathead minnow Bluegill Goldfish Guppy	BSA	–	0.032 (T4A) 0.016 (T4A) 0.027 (T4A) 0.043 (T4A)	a	It was the authors opinion that pH, alkalinity and hardness, within the usual range in natural waters, had little effect on the toxic effect of the compounds studied. The values given are from Henderson, Pickering, and Tarzwell, "The Relative Toxicity of Ten Chlorinated Hydrocarbon Insecticides to Four Species of Fish". It is interesting that the different tables from the above book (as reported in this paper) report widely different values for the same compounds.	Tarzwell (1959)
DDT	Fathead minnow	BSA	–	0.034 (T4A)	a	Comment same as above except that this experiment was performed in hard water.	Tarzwell (1959)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
DDT (50% dust)	Channel catfish (fingerlings)	BSA	–	>2.0 (K 25 hr A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
DDT	*Pimephales promelas*	BSA	–	0.03 (T4A)	a d e f	Concentrations were based on percent active ingredient.	Henderson, et al (1959)
	Lepomis macrochirus			0.02 (T4A)			
	Carassius auratus			0.03 (T4A)			
	Lebistes reticulatus			0.04 (T4A)			
DDT	*Pimephales promelas*	BSA	–	0.042 (T4A)	a b e c d f	Dilution water was usually soft although some studies were conducted with hard water.	Henderson, et al (1959)
	Lepomis macrochirus			0.021 (T4A)			
	Carassius auratus			0.036 (T4A)			
	Lebistes reticulatus			0.056 (T4A)			
DDT (screened)	*Pimephales promelas*	BSA	–	0.026 (T4A)	a b e c d f	Comment same as above.	Henderson, et al (1959)
DDT	*Oncorhynchus kisutch*	BSA	–	(O)	a	This study provides information relating to an extensive field survey conducted to assess the effect of DDT spray deposition on aquatic fauna within the sprayed area. Times to 50% mortality (ET_{50}) were 850 minutes for 0.31 DDT, and 1750 minutes for 0.08 ppm of DDT. Levels of 0.05 ppm may be "safe" for coho salmon inasmuch as this level did not produce death in one week.	Alderdice and Worthington (1959)
DDT (dust)	*Tilapia melanopleura*	FLCH	Tanganyika	1 lb (6.6% K)	–	Trial periods were for 20 weeks. Sublethal effects such as impaired breeding, retarded growth, or altered taste were not detected. Dosages are given as lb/acre of surface water.	Webbe and Shute (1959)
DDT	*Pimephales promelas*	BSA	–	0.032 (T4A)	a	Bioassay investigations of the new insecticides indicate that in general the organic phosphorus compounds are not as toxic to fish as are the chlorinated hydrocarbons. The toxicity of most of these materials was not significantly influenced by water quality. Therefore it is to be expected that the toxicity of these materials will not differ significantly in different streams.	Tarzwell (1959)
	Lepomis macrochirus			0.016 (T4A)			
DDT	Sucker Trout	FR	Mont.	(O)	–	Aerial application rate was 1 lb/acre. Recovery of DDT from streams was 0.01 to 1.2 lb/acre. Surface water 15 minutes after spraying contained 1.35 ppmg. Sub-surface 0.08 ppm, and zero DDT before spraying. Initially, dead fish were mostly suckers, but no trout. Dead trout began appearing 5-6 months after spraying. Trout body tissue contained DDT. Considerable variation was found and no conclusions could be made.	Graham and Scott (1959)

DDT	*Gambusia affinis* *Huro salmoides*	FL	Fla.	(O)	—	Surface applications of DDT as a dust and in oils were not harmful to fish in dosages used for mosquito control (0.1 pound per acre) other cold-blooded aquatic life, such as frogs, snakes, crayfish, spiders, and insects, were obviously affected by suspensions of DDT. No harmful effects on warm-blooded animals in the area were noted. When a small pond was treated with 2.0 ppm of a suspension containing 10 percent each of DDT and Nopco 1216 (sulfonated sperm oil) in cellosolve, at the end of 1 week all fish were killed. A third pond treated with the same formulation at 0.2 ppm killed all the fish in 4 days.	Dupree (1960)
DDT	*Salvelinus fontinalis* *Salmo clarki* *Prosopium williamsoni* *Salmo gairdnerii* *Salmo trutta* *Rhinichthys cataractae*	FR	Mont. & Wyo.	(O)	—	This paper deals with the accumulation of DDT in trout and whitefish after exposure to DDT sprayed over large areas in Montana and Wyoming. The chemical was applied at 1 lb/acre with an average of approximately one-quarter pound per acre reaching the ground and the water. The greatest concentration of DDT was found in fat, followed by kidney, pyloric caecum and brain, in that order. At the given rate of application, this chemical was toxic to all the fish listed.	Cope (1961)
DDT	*Daphnia magna*	BSA	—	0.0014 (O)	a	The indicated concentration immobilized *Daphnia* in 50 hours.	Anderson (1960)
DDT	Salmon	FR	Mitamichi R., N.B., Can.	(O)	—	Spraying with DDT in unspecified amounts markedly reduced the salmon population in this river. In 1954, salmon fry were virtually eliminated and most of the parr were killed.	Kerswill, et al (1960)
DDT (technical, 25% active in xylene)	*Acroneuria pacifica* *Pteronarcys californica* *Claassenia sabulosa* *Arctopsyche grandis*	BSA	—	0.18 (T4A) 0.33 (T4A) 0.01 (T4A) 0.1 (T4A)	a c e f l n	Assays were conducted in hard water.	Gaufin (1961)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
DDT	Brook trout White suckers Crayfish	F	Potter and Tioga Counties, Penn.	(O)	–	DDT was applied as an aerial spray at 0.5 lb/acre. Thirty-two days after spraying, 10.6 ppm was found in brook trout, but 122 days after treatment the amount was at pretreatment level (0.7 ppm). In white suckers, 32 days after treatment, 6.9 ppm was found; and 122 days post-treatment, the concentration had dropped to a pretreatment level (0.24 ppm). Analyses of crayfish were anomalous – in some instances, the pretreatment specimens contained 1.9 ppm or more than 32 days later when the value was 1.1 ppm. This same paper gave some data on the DDF, TDE, and dieldrin content of these same animals.	Cohen, et al (1961)
DDT	*Oncorhynchus kisutch*	BSA	–	44 (T4A)	a c d e	Chemical dissolved in acetone. TL_m expressed in ppb.	Katz (1961)
	Oncorhynchus tshawytscha			11.5 (T4A)			
	Salmo gairdnerii			42 (T4A)			
	Gasterosteus aculeatus			18 (T4A)			
DDT	*Salmo gairdneri*	BSA	–	0.410 (T1A) 0.410 (T2A) 0.395 (T4A)	a c d f g	Hatchery artesian well water was employed for this experiment.	Webb (1961)
DDT	*Aedes aegypti* (larvae)	BSA	–	–	a	Increase in temperature during exposure to DDT (0.02 ppm – 1 hr) increased the toxic action. Additional data are presented.	Das and Needham (1961)
DDT (25 percent EC)	*Gambusia affinis*	FL	Ponds – Bakersfield, Cal.	(O)	a c	At 0.5 lb/acre, 20 percent mortality occurred in 24 hours. At 2.0 lb/acre, 40 percent mortality occurred in 24 hours. The experiments were conducted in cages placed in the ponds.	Mulla and Isaak (1961)
DDT (tech grade emulsified in xylene)	*Hydropsyche californica*	BSA	–	0.048 (T4A)	a c d e l n	Test water was obtained from a mountain stream.	Gaufin (1961)
	Arctopsyche grandis			0.175 (T4A)			
	Acroneuria pacifica			0.41 (T4A)			
	Pteronarcys californica			0.56 (T4A)			
DDT	Ephemeroptera Trichoptera Plecoptera	FR	Mont.	–	–	A large area in Montana was sprayed with 1 pound of technical DDT in 1 gallon of No. 2 diesel fuel per area. The streams draining this area were assayed. It was found that a drastic reduction in all biota took place in Hellroaring Creek and Tower Creek. Pebble Creek, situated away from the test area, served as a control and no reduction occurred. In both Hellroaring and Tower Creeks, repopulation of plecopteran populations occurred leveled by the following year while this did not occur for the other organisms until 3 years had elapsed.	Hastings, et al (1961)

DDT	*Lebistes reticulatus* (Adult) (Young) *Salmo trutta* (2 wk) (10 wk) (11 wk)	BSA	–	 0.018 (T14 A) 0.0024 (T14A) <0.18 (T14A) 0.00056 (T14A) 0.014 (T14A) fingerlings	a	Deep well water was used as diluent. Histological observations were found to be similar for guppies and trout despite age differences, DDT concentration, and exposure periods. Liver: degeneration Kidney: no change in guppy – 1-2 days tubules occluded in trout. Other data and observations presented.	King (1962)
DDT	*Salmo trutta*	BSA	–	0.5 and 0.1 (O)	–	C^{14} labeled DDT was placed in the water at the concentrations listed. Various organs and tissues of the trout were analyzed for DDT. The analytical method is outlined. At 0.5 ppm, one fish died in 18 hours, and another at 160 hours. At 0.1 ppm, one fish died in 30 hours and another at 230 hours. Only two fish were used at each concentration.	Holden (1962)
DDT	Ephemeroptera	FR	Adirondack Mountains	(O)	–	DDT was applied as low as 0.1 lb/acre for effective control of blackfly. There was a small number of Ephemeroptera and Diptera in regularly treated streams, but the reduction in overall numbers did not reach a significant level. The treated and untreated streams were sampled in 1950-52 and in 1961.	Jamnback and Eabry (1962)
DDT	Various insects	FS	Africa	(O)	–	This study showed that the effect of a single application of DDT on an African stream eliminated the majority of aquatic insect species for varying distances. It seems fairly certain, however, that almost all the species survived as eggs, from which the population was replenished. The three major predators were, however, among the most severely affected, and this led to an increase in the principal prey organisms, Baetidae and *Simulium*. This was an effect which has been observed in streams in Europe and North America, and indicates that DDT treatments could lead to severe outbreaks of *Simulium* species. The amount of the DDT sprayed on an area was not specified.	Hynes and Williams (1962)
DDT	*Protococcus* sp *Chlorella* sp *Dunaliella euchlora* *Phaedactylum tricornutum* *Monochrysis lutheri*		–	0.6 (O)* 0.6 (O)* 0.6 (O)* 0.6 (O)* 0.6 (O)* *obvious, but inhibited growth.	a	This paper concerns the growth of pure cultures of marine plankton in the presence of toxicants. Results were expressed as the ratio of optical density of growth in the presence of toxicants to optical density in the basal medium with no added toxicants.	Ukeles (1962)
DDT	Cutthroat trout	FL	Wyo.	(O)	a	Five lots of fish were given DDT once a week in their diets at different rates for each lot. Fish were fed in mg/kg of body weight. Analysis showed that residues of DDT, DDE, and DDD were present in fish fed 3 and 1 mg/kg per body weight. Greatest number of deaths occurred in fish lots fed 3 mg/kg of body weight.	Cope (1963)

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Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
DDT	Rainbow trout Bullhead Crayfish	FL	Colo.	0.02 (O)	–	The pond was treated with DDT at a rate of 0.02 ppm. The concentration of DDT in the pond was at its highest point 30 min after treatment. None could be detected after 21 days. Bullheads and trout contained the greatest amounts of chlorinated hydrocarbon 30-40 days after treatment, with concentrations over 4 ppm. Levels slowly declined after that, averaging 3.5 ppm in samples taken 9 and 10 months after treatment in both species, and 3 ppm in rainbow trout taken 14 months after treatment. Crayfish developed lower DDT residues than did trout, and contained 0.33 ppm after 14 weeks.	Cope (1963)
DDT	*Acris crepitans* *A. gryllus*	Lab	–	(O)	a	Possible resistance to DDT was demonstrated in natural populations of frogs from several Mississippi localities by exposure to different DDT concentrations for 36 hours. Frogs living near cottonfields heavily treated with DDT for several years tended to be less susceptible to the chemical than individuals having little or no prior contact with DDT. The animals were placed on filter paper impregnated with varying amounts of DDT. The data are difficult to average because of the range. It would appear that 30.0 g per liter was the TL_m for 36 hours for *A. crepitans,* and 9.0 g per liter for *A. gryllus* (sic).	Boyd, et al (1963)
DDT	Cladocerans Copepods Ostrocods Rotifers *Volvox*	FL	Minn.	(O)	–	At an application rate of 1 lb/acre, depression of micro-crustacean populations occurred a few days after application. but this was followed by an apparent rapid recovery.	Jones and Moyle (1963)
DDT	*Culex pipiens quadrimaculatus*	BSA	–	(O)	c	Tests were conducted in tap water and artificially polluted tap water. The values reported are the concentration range for an LC_{90}, 0.12 to 0.55 ppm for polluted and 0.33 to 128.0 ppm for tap water.	Lewallen and Wilder (1963)
DDT EC 2	*Rana catesbeiana* (tadpoles)	FL	Cal.	1.0 (O)	a c	Mixed populations of the indicated test species contained in cages were exposed to various insecticidal chemicals applied as dilute sprays to ponds 1/16 acre in size. The indicated toxicant concentration is in lb/acre, and resulted in a 30 percent mortality for the tadpoles in 24 hr.	Mulla (1963)
DDT (tech)	*Procambarus clarki*	BSA	–	0.6 (T3A)	a c d o	There was no detectable difference in toxicity to male or female crawfish.	Muncy and Oliver (1963)
DDT (anti-resistant 50 percent WP)	*Salmo gairdneri*	BSA	–	24 (T1A) 21 (T2A) 16 (T4A)	a	The experiments were conducted at 55 F. Fish were 2-3 in. long.	Cope (1963)

DDT (anti-resistant 25 percent EC)	*Salmo gairdneri*	BSA	–	10 (T1A)	a	Comment same as above.	Cope (1963)
DDT, p-p'	*Salmo gairdneri*	BSA	–	18 (T 18 hr) 11 (T 32 hr) 10 (T 56 hr)	a	Comment same as above.	Cope (1963)
				10 (T1A)		Comment same as above.	
				10 (T1A)		The experiment was conducted at 65 F. Fish weighed 0.6 g.	
				6.0 (T1A)		The experiment was conducted at 65 F. Fish weighed 0.4 g.	
				5-6 (T1A)		The experiment was conducted at 75 F. Fish weighed 1.5 g.	
	Lepomis macrochirus			6.0 (T1A)		The experiment was conducted at 75 F. Fish weighed 0.4 g.	
	Redear			19 (T1A) 15 (T1A)		The experiment was conducted at 75 F. Fish weighed 3 g.	
DDT	Rainbow trout Long-nose sucker Cutthroat trout Brown trout Brook trout Mountain whitefish	BSA	–	(O)	a d g	Hatchery trout under 3.1 inches in length had a mortality rate of 100% at all concentrations for 0.5 to 10.0 ppm. The mortality rate decreased as size increased (66% for those over 5 inches). Wild rainbow trout under three inches had a mortality of 24%. Hatchery trout showed a 50 to 75% higher mortality than the wild trout. A comparison of six species of cold-water fish over four inches in length tested in 1 ppm DDT showed that the long-nosed sucker had a mortality rate of 94%, while the rainbow trout, cutthroat trout, brown trout, brook trout, and mountain whitefish had a mortality rate of less than 10%.	Schoenthal (1963)
DDT	*Gambusia affinis*	BSA	–	0.05-0.10 (O)	–	Mosquito fish from waters near cotton fields that have a long history of treatment with chlorinated hydrocarbon pesticides exhibited a marked resistance to DDT compared with fish from areas which had had no past exposure to insecticides. As an example, for a DDT concentration of 0.05 ppm: 72 hours 90% mortality occurred for fish from untreated areas 72 hours 25-28% mortality occurred for fish from DDT treated ponds.	Vinson, et al (1963)
DDVP (tech)	*Salmo gairdneri*	BSA	–	500 (T1A)	a	The experiment was conducted at 55 F. Fish were 2-3 in. long.	Cope (1963)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
DDT	*Salmo lewisi clarki*	BSA	–	(O)	a c e f	This experiment concerns the periodic exposure of fish to different levels of DDT in bath and in food over a 20-month period involving one spawning cycle. It was decided that a threshold level exists around 0.1 ppm monthly in contact form and around 0.3 mg DDT per Kg of fish weekly in the diet for the toxic effects of DDT. Fish lots given 0.1 ppm DDT monthly in bath form exhibited significantly higher mortality, similar size, and similar reproductive success when compared with the control group. Fish lots treated weekly with DDT in the diet at the rate of 0.3 milligrams per kilogram of body weight did not differ from the control except, in a highly variable manner, residue buildup, and a nonsignificant increase in mortality during the last few months of the experiment.	Allison, et al (1964)
DDT	*Ophicephalus punctatus*	BSA	–	1.0 (K)	–	Experiments were conducted in a trough containing 3500 cc of water sprayed with 1 cc of a 25% DDT emulsion. Liver and intestines were examined for residues and both were found to contain 0.08083 g of DDT. When 5 cc of a 25% DDT emulsion was sprayed, the fish died in 2 hr. The fish were found to contain 0.1344 g of DDT residue in the intestine and 0.1292 g in the liver.	Mathur (1964)
	Barbus stigma			(O)		When 5 cc of a 25% DDT emulsion was sprayed in a small jar containing 2 liter of water, death occurred in 2 hr and 30 min. Residues found were 0.06523 g of DDT in liver and 0.07799 g in intestines.	
DDT	*Notemigonus crysoleucas* *Lepomis macrochirus* *L. cyanellus*	BSA	–	(B) 0.032 (T 1.5) (A) 0.028 (T 1.5) (B) 0.028 (T 1.5) (A) 0.033 (T 1.5) (B) 25 (T 1.5) (A) 22 (T 1.5)	a c f	Chemical was dissolved in acetone. Final concentration of acetone was <2 ml/l. Data shows TL_m ppb for insecticide-resistant (A) and insecticide non-resistant (B) strains of the test fish.	Ferguson, et al (1964)
DDT (tech, 98 percent active in acetone)	*Pteronarcys californica* (naiad) *Acroneuria pacifica* (naiad)	BSA	–	1.8 (T4A) 0.32 (T4A)	c d e f	*A. pacifica* was much more sensitive to chlorinated hydrocarbons and to organic phosphate insecticides than *P. californica.*	Jensen and Gaufin (1964)
DDT	*Gammarus lacustris*	BSA	–	0.009 (T4A)	a e	Emulsible concentrates were prepared from technical grade insecticides with acetone as the solvent. Symptoms prior to death were observed and recorded on graphs.	Nebeker and Gaufin (1964)
DDT	Bluegill	BSA	–	0.016 (T4A)	a	Assays were conducted in soft water at 25 C. Decrease in brain cholinesterase was measured in fish exposed to the toxicant.	Weiss (1964)

DDT	Trout: brown and rainbow *Cottus* sp Trichoptera Plecoptera Coleoptera Diptera Ephemeroptera	FR	Mont.	0.02 mg/l	–	The application rate was 0.5 lb/acre. Before and after spraying, determination of DDT concentrations was made on fish homogenates. Dead fish found after spraying were found to contain up to 0.6 mg/kg DDT. However, live fish caught were found to contain up to 3.4 mg/kg DDT. Fish kills occurred up to 48 hours after spraying. Extensive mortality of aquatic insects occurred, but not consistently throughout sprayed area of river.	Welch and Spindler (1964)
DDT	*Salmo gairdnerii* *Ictalurus punctatus* *Lepomis macrochirus* *Pteronarcys californica*	BSA	–	1.5 (T4A) 3.3 (T4A) 4.7 (T4A) 7.0 (T4A)	a c d	Toxicity values reported as median lethal conc. (LC_{50}) for 24, 48, 96 hr.	Bridges and Cope (1965)
DDT + Toxaphene	Oyster	BCF	–	0.030 (O)	a	The value reported is a 96-hr EC_{50} (decreased shell growth).	Butler (1965)
DDT	Oyster	BCH	–	(O)	–	Oysters exposed to DDT at a concentration of 0.0001 ppm contained 70,000 times that concentration after 40 days. Oysters exposed to the chemical at 0.001 ppm for 12 days contained 12 to 20 ppm. Because the oyster can concentrate DDT so readily, it is an organism of choice to use in monitoring for pesticide pollution.	Butler (1965)
DDT	*Cyprinodon variegatus* (juvenile)	BSA	–	0.005 (O)	a	Water temperature was 9 C. The figure reported is a 48-hr EC_{50}.	Butler (1965)
	Fundulus similis (juvenile)			0.018 (O)		Water temperature was 21 C.	
DDT + Strobane	Oyster	BCF	–	0.022 (O)	a	The value reported is a 96-hr EC_{50} (decreased shell growth).	Butler (1965)
DDT	Blue crab	BCH	–	(O)	–	DDT at a concentration of 0.001 ppm kills crabs in 8 days. Crabs can live and grow in a concentration of 0.00025 ppm.	Butler (1965)
DDT	Rainbow trout	BSA	–	4.1 (T4A) 5.0 (T4A) 6.0 (T4A)	a	These experiments were performed to show the effect of temperature on the toxicity. For the toxicant concentrations listed, the temperatures were respectively 45, 55, and 65 F. The fish all were approximately one gram in weight. Toxicant concentrations for one and 2-day times were also listed.	Cope (1965)
DDT	*Palaemonetes kadiakensis*	BSA	–	(N) 4.5 (T1-1/2A) (TB) 10 (T1-1/2A)	a c f	Test organisms were collected from 2 locations, Twin Bayou (TB), Sunflower Co., Miss. (agricultural area) and Noxubee National Wildlife Refuge (N), Noxubee Co., Miss. (non-agricultural area) and evaluated in laboratory bioassays. The Twin Bayou shrimp were more resistant.	Ferguson, et al (1965)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
DDT	*Gambusia affinis* *Ictalurus melas*	BSA	–	0.008-0.023 (T3A) 0.009-0.275 (T3A)	a c d e	Test fish were collected from 8 different locations of the Mississippi River. The 3-day TL_m values were made to determine if a resistance gradient existed. The data indicated that there was none.	Ferguson, et al (1965)
DDT	*Lepomis cyanellus* *Gambusia affinis* *Ictalurus melas*	F	Miss.	0.52 (O)	–	Muds reduced the toxicity of chlorinated hydrocarbon insecticides to fish. Lethal quantities of pesticides enter national waters and muds may contain sorbed pesticides in excess of lethal quantities. Although the chemicals can be leached with organic solvents, they were either not released in lethal amounts or slowly released in standing water.	Ferguson, et al (1965)
DDT	*Arctopsyche grandis* *Pteronarcys californica* *Acroneuria pacifica* *Ephemeralla grandis* *Hydropsyche californica* *Daphnia magna* *Gammarus lacustris* Bluegill Fathead minnows	BSA	–	0.18 (T4A) 1.8 (T4A) 0.3 (T4A) 0.03 (T4A) 0.05 (T4A) 0.001 (T 50 hr A) 0.009 (T4A) 0.03 (T4A) 0.03 (T4A)	a	Unspecified chemical characteristics of assay water were determined by standard methods. General comments were made concerning "standardized" conditions, use of "soft" water, and use of emulsifying agents. Additional data are presented.	Gaufin, et al (1965)
DDT	*Acroneuria pacifica* *Ephemerella grandis* *Gammarus lacustris* *Pteronarcys californica*	BSA	–	0.32 (T4A) 0.025 (T4A) 0.009 (T4A) 1.8 (T4A)	a c	Additional TL_m data are given.	Gaufin, et al (1965)
DDT	*Salmo salar*	BCFCH	–	0.005-0.05 (O)	a e	The fish were exposed to the reported sub-lethal doses for 24 hours. Low dosages of DDT produced a downward shift in the temperature response whereas higher doses produced an upward shift.	Ogilvie and Anderson (1965)
DDT	Fish Shell fish Birds Mice	FLR	Conn.	(O)	–	The results showed that DDT was present in animals in areas where no spraying had been conducted. Analyses showed the following: Whole fresh fish – 0.1 to 0.9 ppm DDT Shell fish – 0.031 to 0.07 ppm Birds – 0.1 to 0.8 ppm Mouse kidney fat – 1.01 to 8.19 ppm	Turner (1965)

DDT	Brown trout	BSCH	–	0.10 (O)	–	Data given on DDT concentrations in various tissues on weight basis are as follows: Brain 0.6 ppm Muscle 0.7 ppm	Weiss (1965)
DDT	Oysters Adult Larvae	BCF	–	— (O) 1.0 (K6)	a	Sea water was employed in this experiment. As the concentration of DDT increased from levels of 1.0 ppb to 1.0 ppm, there was a logarithmic decrease in the rate of oyster shell growth from about 20 to 90 percent.	Butler (1966)
DDT	*Crassostrea virginica*	BCF	–	(O)	a	Tests were conducted in flowing seawater. DDT in levels as low as 0.001 ppm caused marked reduction in oyster growth.	Butler (1966)
DDT	*Salmo gairdnerii* *Lepomis macrochirus* *Ictalurus punctatus* *Pteronarcys californica* *Baetus* sp *Daphnia pulex* *Simocephalus serrulatus*	BSA	–	0.005 (T2A) 0.005 (T2A) 0.012 (T2A) 0.016 (T2A) 0.012 (T2A) 0.0004 (T2A) 0.002 (T2A)	a	This paper reports acute toxicity of a number of compounds, and discusses sub-acute mortality as well. Effects on reproduction and behavior are also discussed. Data presented as EC_{50}.	Cope (1966)
DDT	*Cyprinodon variegatus*	BSA	–	0.020 (O) 0.030 (O) 0.040 (O)	a e i	A concentration of 0.020 ppm caused 80% mortality, 0.030 caused 87% mortality, and 0.040 caused 97% mortality in 24 hr.	Holland, et al (1966)
DDT	*Gambusia affinis*	BSA	–	(O)	a	The effect of combinations of pesticides was studied. In general, the results reflected the extreme levels of Endrin and Toxaphene resistance in the resistant population. The results failed to indicate additive effects wherein the combination mortality exceeded the sum of the mortalities produced by the individual insecticides.	Ferguson and Bingham (1966)
DDT	*Pygosciles adeloriae* *Lobodon carcinophagus*	FM	Ross Island, Antarctic	(O)	a	Adult penguins assayed had residues ranging from 0 to 8 ppb. The pre-molts examined had residues ranging from 1 to 16 ppb in the liver, and 0 to 69 ppb in the fat. The crab-eater seal examined showed residues of 4 ppb in the liver and 15 ppb in the fat.	George and Frear (1966)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
p,p' -DDT	*Salmo gairdnerii*	BSA	–	0.0107 (T4A)	a	Data are given for various lots within each species of fish obtained from different sources. However, a mean was given which is reported here. Data for fathead minnows were not consistent. The toxicity did not increase uniformly with increased concentrations up to 1.0 ppm.	Marking (1966)
	S. trutta			0.0109 (T4A)			
	Salvelinus fontinalis			0.0115 (T4A)			
	S. namaycush			0.093 (T4A)			
	Esox lucius			0.0017 (T4A)			
	Carassius auratus			0.0587 (T4A)			
	Chrosomus eos			0.0680 (T4A)			
	Cyprinus carpio			0.0082 (T4A)			
	Pimephales promelas			(O)			
	Ictalurus punctatus			0.0175 (T4A)			
	Eucalia inconstans			0.0670 (T4A)			
	Lepomis cyanellus			0.0045 (T4A)			
	Lepomis gibbosus			0.0045 (T4A)			
	L. macrochirus			0.0045 (T4A)			
	L. megalotis			0.0087 (T4A)			
	Micropterus salmoides			0.0008 (T4A)			
	Perca flavescens			0.0009 (T4A)			
	Aplodinotus grunniens			0.0100 (T4A)			
	I. melas			0.0258 (T4A)			
DDT	*Simocephalus serrulatus*	BSA	–	0.0025 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 48 hr. Data cited are for 60 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
	Daphnia pulex			0.00036 (SB)			
DDT	*Daphnia magna*	BSA	–	0.0044 (SB)	–	Comment same as above.	Sanders and Cope (1966)
DDT	*Daphnia carinata*	BSA	–	0.0022 (SB)	–	Comment same as above.	Sanders and Cope (1966)

DDT	*Oncorhynchus kisutch*	BSA	–	0.024 (T2A) 0.013 (T4A)	a c e j k	DDT at the given concentrations seemed to cause a coughing reaction in the fish. It was theorized that this coughing reaction was a reversal of the water flow over the gills as a gill cleansing reaction.	Schaumberg (1967)
DDT	*Tubifex* spp *Limnodrilus* spp	BSA	–	100 (L4A)	a c e	Toxicity is reported as the mean lethal dose (LD_{50}) for 24, 48, and 96 hours.	Whitten and Goodnight (1966)
DDT	*Salmo gairdnerii* *Rasbora heteromorpha*	BSA	–	(O) (O)	f	This report derives as mathematical equation for determining a threshold concentration of a toxicant. For many toxins, the rate of mortality is a linear function of the concentration. The value of 0.02 ppm of DDT was obtained by interpolation from three different curves for the trout. The tests were conducted in hard water. A value of 0.04 ppm for harlequin fish was also obtained by interpolation from a graph.	Abram (1967)
DDT (mixed isomers)	*Salmo gairdnerii* *Rasbora heteromorpha*	BCFA	–	0.0015 (threshold)	a d e	Aerated hard water was used. Threshold concentrations were examined by 4 methods. 1. Long term – survival related to concentration. 2. Short term – percentage kill in narrow range of concentrations. 3. Comparison of survival times. 4. Extrapolation of short-term results by plotting velocity of death against log of concentration.	Abram (1967)
DDT	*Mya arenaria* *Crassostrea virginica*	BSCH	–	(O)	–	Oysters were exposed to 2.0 to 4.0 ppm DDT and then fed to shrimp and fish. At the end of 2 to 4 weeks, at least 50 percent of the experimental animals died. *M. arenaria* (soft clam) proved to be the most sensitive or efficient in storing organochloride residues.	Butler (1967)
DDT	*Mya arenaria* *Crassostrea virginica* *Corbicula manillensis* *Mercenaria mercenaria* *Rangia cuneata*	BCFCH	–	(O)	–	Results are recorded as a range of uptake of the chemical by 5 species of aquatic mollusks. An uptake or concentration of 1200-9000X resulted.	Butler (1967)
DDT	Aquatic insects: Ephemeroptera Diptera, Simulidae Plecoptera Trichoptera	FR	Ontario, Can.	(O)	–	This is a review paper on the effect of DDT in the reduction of insects, and the time it takes a population to reestablish itself. The area was sprayed with DDT at a rate of 0.5 lb/acre. Most organisms recovered to normal populations within 2-3 years, but caddisflies required 4 or more years.	Ide (1967)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
DDT	*Leptonychotes weddelli*	FM	Antarctic	(O)	a	All residues are expressed as ppm wet weight. It was established that residues in the water were less than 0.0005 ppm. *L. weddelli* contained residues ranging from 0.042 to 0.12 ppm in fat. No residues were found in other tissues. Adult *P. adeliae* contained residues of 0.015 to 0.018 ppm of DDT in fat. *C. skua maccormicki* contained residues ranging from 0.01 to 0.68 in 9 tissues examined. *A. forsteri* adults were examined for residues and found to contain none. Ten *R. dearborni* were examined and found to contain an average of 0.44 ppm DDT residue. *T. bernacchii* and *T. hansoni* were examined and contained no residues. It was established that there were no residues at levels as high as 0.005 ppm in invertebrates.	George and Frear (1966)
	Pygoscelis adeloriae			(O)			
	Catharacta skua maccormicki			(O)			
	Aptenodytes forsteri			(O)			
	Rhigophila dearborni			(O)			
	Trematomus bernacchii			(O)			
	T. hansoni			(O)			
	Invertebrate samples Arthropoda Echinodermata Nermertinea Mollusca			(O)			
DDT (prills)	Amphipoda Elmidae Grypopterygidae Turbellaria Oligochaeta Gastropoda Decapoda Odonata Plecoptera Ephemeroptera Hemiptera Trichoptera Megaloptera Coleoptera Diptera Anguillidae Galaxiidae Eleotridae	FR	New Zealand (4 streams)	(O)	–	DDT prills were applied from the air to 200 acres of sheep pasture. The mean weight of active DDT reaching the ground was 61.3 mg/square meter. Changes in the fauna of streams draining the treated pasture were studied for 12 months after the application. A high mortality was found in most of the aquatic insect fauna with the exception of Elmidae (Coleoptera) and Grypopterygidae (Plecoptera). Amphipoda were virtually wiped out. At the end of the investigation large number of insects were again present but with a completely altered species composition. Mortality to freshwater crayfish was doubtful, and unproven for fish. The levels of DDT found in whole fish are discussed.	Hopkins, et al (1966)

DDT and "organo-chlorine residues"	*Pontoporeia affinis* *Alosa pseudoharengus* *Coregonus clupeaformis* *Leucichthys* sp	FLCH	Wisc.	–	–	Pesticide residues were determined in mud sediments, insects, fish, and birds. Conclusions were that the pesticides do not stay on land but are accumulated and concentrated in moderately large lakes. Residues found in mud bottoms were: DDT = 0.14 ppm DDE = 0.24 ppm TDE = 0.03 ppm Residues found in: Gull food – Insect – DDT = 0.12 ppm; DDE = 0.49; TDE = 0.06 Alewives – DDT = 1.13 ppm; DDE = 1.77; TDE = 0.43 Fish – Chub – DDT = 1.6; DDE = 2.3; TDE = 0.29 Whitefish – DDT = 1.7; DDE = 2.7; (muscle) TDE = 0.75. Additional residue data are presented.	Hickey, et al (1966)
DDT	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	–	0.04 (O)	a	Stones heavily populated with larvae were placed in troughs of running water containing the toxicant. When the larvae became detached from the rocks and floated away, they were assumed to have undergone lethal intoxication. The larvae were exposed to the toxicant for 5 minutes, then in clean water for 24 hours. At that time the number detached amounted to 52 percent.	Jamnback and Frempong-Boadu (1966)
DDT	Fish	F	Cal.	(O)	–	This study was primarily concerned with insecticides found in fish-eating birds. Limited fish studies were also conducted. DDT was found in trace to 1.6 ppm concentrations in whole fish (wet weight).	Keith (1966)
pp DDT	*Buteo buteo* *Accipiter gentilis* *Accipiter nisus* *Falco tinnunculus* *Tyto alba* *Strix aluco* *Osio otus* *Falco pereginus*	FO	Netherlands	(O)	–	The results of this study show that birds of prey and fish-eating birds found dead in the Netherlands accumulated large amounts of different chlorinated hydrocarbon insecticides. In most cases the liver had the highest concentration of toxicant, ranging from 1.6 ppm.	Koeman and van Genderen (1966)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
DDT	*Crassostrea virginica* *Pseudomonas piscicida*	BCFCH	–	(O) 10 (SB)	a	At 0.00001 ppm concentration, 0.11 ppm residue was found in 20 days. At 0.000001 ppm concentration, 0.085 ppm residue was found in 20 days. After extended periods of time, small amounts of DDT actually stimulated growth of *P. piscicida*.	Butler and Johnson (1967)
DDT	Oyster	FE			–	The chemical was found in the water at a concentration of <0.001 ppm. Oysters from the area were found to contain <0.01 to 0.05 ppm.	Casper (1967)
DDT	Stream insects: Ephemeroptera Odonata Plecoptera Trichoptera Neuroptera Coleoptera Diptera	FR	Maine	(O)	–	At an application rate of 1/2 to 1.0 pounds per acre, DDT produced marked reductions in the quality and quantity of the invertebrate fauna. Normally present fauna usually repopulate in 2-4 years. Thirty-nine genera of aquatic insects were studied.	Dimond (1967)
p-p' DDT	Goldfish	BSA & CH	–	50 m g/ml (K)	–	Test fish were conditioned to alkyl benzene sulfonate (4 μg/ml) or sodium lauryl sulfate (4 μg/ml, for various periods of time, then exposed to pesticides. Chronic exposure to the detergent increased the toxicity of the pesticide.	Dugan (1967)
DDT	Atlantic salmon	F	St. Andrews, New Brunswick	(O)	–	After spraying DDT at the rate of 1/2 lb/acre, all young salmon were reduced in number. Underyearlings were only 2-10% as abundant, small parr 30% as abundant, and long parr 50% as abundant. Spraying at the rate of 1/4 lb/acre reduced the numbers of underyearlings by 50%, small parr by 20%, but hardly affected large parr. Spraying with DDT at 1/4 lb per acre, applied twice, was followed by low numbers of underyearlings, similar to the effect of spraying at 1/2 lb/acre. No equivalent data for parr was available.	Elson (1967)
DDT-C^{14}	*Lepomis macrochirus* *Carassius auratus*	BCFCH	–	(O)	a	Fish were treated with carbon-labeled insecticides (0.03 ppm) from 5 to 19 hr and uptake rates were determined. They were placed in recovery tanks for up to 32 days. Whole body samples were then made. It was found that in both fish species >50 percent of the DDT absorbed was present after 32 days.	Gakstatter and Weiss (1967)
DDT	Aquatic insects: Diptera Trichoptera Ephemeroptera Chironomidae	FR	Mitamichi River, New Brunswick, Canada	–	–	Young salmon, both fry and parr, were seined and the stomachs removed. Insects were removed from the stomachs identified and counted. Forage ratios of the insects were determined and reported for 1953-1961. Reduction of all insects by DDT was soon followed by resurgence of Chironomidae and other Diptera. Five years after the spraying, the pre-spraying complexity of food for younger salmon was approached. Trichoptera were the slowest to reappear.	Keenleyside (1967)

DDT	*Salmo salar*	FR	St. Andrews, New Brunswick	(O)	–	DDT at 0.25 lb/acre killed many insects and some fish, but was only about half as damaging to aquatic fauna as a heavier dosage (0.5 lb). After spraying at 0.5 lb/acre, young salmon of all size groups were found in reduced numbers.	Elson and Kerswill (1967)
DDT	Atlantic salmon Brook trout Sucker Cyprinids	FR	New Brunswick	(O)	–	When DDT in an oil emulsion was sprayed at 0.5 lb/acre, heavy losses in underyearling salmon and parr were observed. Wild young salmon were found in streams when autumn water temperatures approached freezing after June sprayings with DDT. Spraying with DDT at 0.25 lb/acre had no effect on caged, or native fish during a period of 2 or 3 weeks after spraying. In one area suckers and cyprinids were extensively killed after 0.5 lb/acre spraying of DDT.	Kerswill and Edwards (1967)
pp'DDT	*Esox lucius*	FR	River Nene, Eng.	(O)	–	Higher concentrations were found in larger fish, indicating that they had been exposed to the pesticides for a longer time. Tissue extracts from the pike were analyzed for organochlorine pesticide residues by gas liquid chromatography. The values for large pike were: 0.068 ppm muscle 6.7 ppm fat	Mawdesley-Thomas and Leahy (1967)
op'DDT	*Esox lucius*	FR	River Nene, Eng.	(O)	–	Comment same as above except that: 0.38 ppm muscle 52.0 ppm fat	Mawdesley-Thomas and Leahy (1967)
DDT	*Puntius puckelli*	BSA	–	0.048 (T4A)	a c d e l m	Tap water was used as diluent. Toxicity data are given as TL_m's in ppm for 24, 48, 96 hr. The pH of the water averaged at 8.3. The study was conducted in India.	Rao, et al (1967)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
DDT	Plankton	FECH	Long Island, N. Y.	0.040 (O)	–	DDT residues in soil of the defined estuary area averaged more than 13 pounds per acre with a maximum of 32 pounds per acre. These values are based on the wet weight of the whole organism.	Woodwell, et al (1967)
	Cladophora gracilis			0.083 (O)			
	Shrimp			0.16 (O)			
	Opsanus tau (immature)			0.17 (O)			
	Menidia menidia			0.23 (O)			
	Crickets			0.23 (O)			
	Nassarius obsoletus			0.23 (O)			
	Gasterosteus aculeatus			0.26 (O)			
	Anguilla rostrata			0.28 (O)			
	Flying insects, mostly Diptera			0.30 (O)			
	Spartina patens			0.33 (O)			
	Mercenaria mercenaria			0.42 (O)			
	Cyprinodon variegatus			0.94 (O)			
	Fundulus heteroclitus			1.24 (O)			
	Paralichthys dentatus			1.28 (O)			
	Esox niger			1.33 (O)			
	Strongylura marina			2.07 (O)			
	Spartina patens			2.80 (O)			
DDT	*Lampsilis siliquoidea* *L. ventricosa* *Anodonta grandis*	FR	Red Cedar River, Mich.	(O)	–	The amount of the chemical sprayed in the area was not specified. Residue in plants ranged from 0.7 to 10.0 ppb. Algae contained 0.4 to 3.0 ppb. Chubs contained 2.5 to 17 ppb. Bass – 6.0 to 50.0 ppb. Clams 1.0 to 4.0 ppb. The water contained 0.002 to 0.027 ppb.	Godsil and Johnson (1968)
DDT	Vascular plants Algae Chubs Largemouth bass Clams	FL	Tule Lake, Ore.	(O)	–	The mussels listed were analyzed for the toxicant and its metabolites. Mussels may be used as detectors for this toxicant, because they tend to concentrate the chemical in much higher concentrations than it is ever found in the water. The amount of chemical applied as a spray was not specified.	Bedford, et al (1968)

DDT (and analogues)	*Limnephilus rhombicus* *Sialis* sp *Gammarus* sp *Salvelinus fontinalis* *Semotilus atromaculatus* *Cottus bairdi* *Rhinichthys atratulus*		Knights Creek, Wisc.	(O)	–	Pesticide usage in an orchard did not significantly contaminate the aquatic environment of this creek adjacent to the treatment as determined by residue analysis.	Moubry, et al (1968)
DDT	*Alosa pseudoharengus* *Aplodinotus grunniens* *Coregonus artedii* *Lota lota*	BSA	–	(O)	–	The study showed that the levels of chlorinated hydrocarbon pesticide residues in fish meals and oils were, with the exception of the oil sample taken from the Lake Michigan alewife, below the regulatory tolerances established by the Food and Drug Directorate of Canada (1965) for certain foods intended for human consumption. Pesticide levels were interpreted as being representative for each species.	Dugal (1968)
DDT	*Salmo salar L.*	BCFA	–	(O)	a	Fish were conditioned for at least 60 days at 12-16 C in flowing water in the laboratory. The largest group, 20 parr with an average weight of 2.5 g, was killed in 9 hr by an aqueous suspension of 2.0 ppm p,p-DDT; 9 parr of the same size-group died in about 75 hr while in a 0.1 ppm suspension; 7 smaller parr (1.4 g) kept in a 0.01 ppm suspension, died in about 23 hours	Greer and Paim (1968)
DDT	*Salvelinus fontinalis*	BSA	–	(SB)	a c d e p	When sexually maturing yearling brook trout were fed for 156 days with DDT at sublethal rates, fish fed at the lower dosages produced more mature ova than untreated fish. Those fed at highest dosages produced fewer mature ova than untreated fish. The size of the male fish at the end of the feeding period tended to increase according to the dosage of DDT.	Macek (1968)
o,p-DDT	*Potamogeton pectinatus* *Cladophora* *Oscillatoria* *Cynodon dactylon* *Arundo donax*	FR	Ariz.	(O)	–	Irrigation canals were examined for plants which might serve as DDT collectors or indicators of DDT usage by concentrating this material and its metabolites. Highest residues were found in *Cladophora* (19 ppm), followed by *Potamogeton* (9 ppm), and finally *Oscillatoria* (5 ppm).	Ware, et al (1968)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
p,p'-DDT	*Potamogeton pectinatus* *Cladophora* *Oscillatoria* *Cynodon dactylon* *Arundo donax*	FR	Ariz.	(O)	—	Irrigation canals were examined for plants which might serve as DDT collectors or indicators of DDT usage by concentrating this material and its metabolites. Highest residues were found in *Cladophora* (19 ppm), followed by *Potamogeton* (9 ppm), and finally *Oscillatoria* (5 ppm).	Ware, et al (1968)
p,p'-DDT	*Alosa pseudoharengus* *Aplodinotus grunniens* *Coregonus artedii* *Lota lota*	BSA	—	(O)	—	The study showed that the levels of chlorinated hydrocarbon pesticide residues in fish meals and oils were, with the exception of the oil sample taken from the Lake Michigan alewife, below the regulatory tolerances established by the Food and Drug Directorate of Canada (1965) for certain foods intended for human consumption. Pesticide levels were interpreted as being representative for each species.	Dugal (1968)
DDT	*Pteronarcys californica* (naiads)	BSA	—	0.0070 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
	Pteronarcella badia (naiads)			0.0019 (T4A)			
	Claassenia sabulosa (naiads)			0.0035 (T4A)			
DDT	*Skeletonema costatum* *Coccolithus hyxleyi* *Pyramimonas* sp *Peridinium trochoideum*	L & CH	—	(O)	a	Algal photosynthesis was reduced, as measured by $^{14}CO_2$ uptake. It was decreased at concentrations of a few ppb of DDT.	Wurster (1968)
DDT	*Salvelinus fontinalis*	BCH	—	0 to 0.60 (SB)	a e	All experiments were conducted in 6 liters of water. When brook trout are exposed for 24 hr to sublethal doses of DDT, the cold-blocking temperature for a simple reflex, which shows lability related to thermal history, is altered in a way suggesting that DDT is affecting the thermal acclimation mechanism. Sublethal dosage of DDT also prevents the establishment of a visual conditioned avoidance response.	Anderson and Peterson (1969)

DDVP	*Micropterus salmoides*	BSA		0.5 (O)	–	The degree of reaction to the cholinesterase-inhibiting insecticides is not only a function of time and concentration, but also of chemical and biological species. This paper reports many analyses of brain cholinesterase activity which is expressed as percentage of normal. The data are reported as LT_{50} which was the time required for 0.5 ppm of the chemical to kill 50 percent of the fish. For bass the LT_{50} was 48 hr and for the fathead 72 hr.	Weiss (1961)
	Pimephales promelas			0.5 (O)			
DDVP	*Salmo gairdnerii* (one wk old sac fry)	BSA	–	1.0 (K 0%) 10 (K 100%)	a e	Results are averages of triplicate tests. Toxicity is reported as percent mortality (K %).	Lewallen and Wilder (1962)
	(one mo old feeding fry)	BSA	–	1.0 (K 0%) 10 (K 100%)			
DDVP, Tech.	Bluegill	BSA	–	0.480 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
DDVP	*Pteronarcys* sp (nymphs)	BSA	–	0.0001 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
DDVP	*Simocephalus serrulatus*	BSA	–	0.00026 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 48 hr. Data cited are for 60 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
	Daphnia pulex			0.000066 (SB)			
DDVP	*Trichogaster fasciatus*	BSA	–	3 (K7)	a	All the organisms listed are detrimental to culture of carp. At the concentrations listed, there was 100 percent kill of the organisms in 7 days.	Srivastava and Konar (1966)
	Chana punctatus			3 (K7)			
	Mastocembelus pancalus			5 (K7)			
	Macrognathus aculeatum			5 (K7)			
	Nandus nandus			5 (K7)			
	Rita rita			5 (K7)			
	Amphipnous cuchia			5 (K7)			
	Mystus vittatus			10 (K7)			
	Puntius sophore			10 (K7)			
	Esomus danrica			30 (K7)			
	Labeo rohita			30 (K7)			
	Sphaerodema annulatum			0.1 (K7)			
	Nepa sp			0.5 (K7)			
	Ranatra filiformis			0.2 (K7)			
	Dytiscus sp			0.1 (K7)			
	Hydrophilus sp			0.5 (K7)			
	Anisoptera			0.2 (K7)			

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DDVP	*Cyprinus carpio*	BSA	–	15.0 (T2A)	a c d e f p	The test animals were conditioned for 48 hours prior to use.	Sreenivasan and Swaminathan (1967)
	C. carpio			5.5 (T2A)			
	Tilapia mossambica			3.0 (T2A)			
	Cirrhina mrigala			25.0-30.0 (T2A)			
	Labeo fimbriatus			18.0 (T2A)			
	Frog tadpoles			10.0 (T2A)			
Dead X (95 percent naphtha)	*Pteronarcys* sp (nymphs)	BSA	–	2.0 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Dead-X (EC)	Rainbow trout Bluegill	BSA	–	8.8 (T4A) 9.2 (T4A)	a	This is an estimated LC_{50} value at temperatures from 55 to 75 F.	Cope (1965)
Dead-X	*Simocephalus serrulatus*	BSA	–	7.60 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1968)
	Daphnia pulex			3.70 (SB)			
Dead-X (95 percent naphtha)	*Pteronarcys californica* (naiads)	BSA	–	0.0023 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Deet	*Prosimulum* spp *Chephia* spp *Simulium* spp (larvae)	LCFA	–	4.0 (O)	a	Stones heavily populated with wild larvae were placed in troughs of running water containing the toxicant. When the larvae became detached from the rocks and floated away, they were assumed to have undergone lethal intoxication. The larvae were exposed to the toxicant for 5 minutes, then in clean water for 24 hours. At that time, the number detached amounted to 0.0 percent.	Jamnback and Frempong-Boadu (1966)
DEF	*Leiostomus xanthurus* (juvenile)	BSA	–	0.24 (O)	a	Water temperature 27 C. The figure reported is a 48-hr EC_{50}.	Butler (1965)
DEF	*Penaeus aztecus*	L	–	0.028 (O)	a	Toxicant chemicals were evaluated in seawater at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality.	Butler (1965)

DEF	*Crassostrea virginica*	BCFA & BSA	–	0.1 (O)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1966)
	Penaeus aztecus			0.03 (O)			
	Penaeus duorarum						
	Penaeus setiferus						
	Leiostomus xanthurus			0.24 (T2CFA)			
	Phytoplankton			75% (O)			
DEF	Oyster	BCF	–	0.1 (SB4)	a	Seawater was employed in this experiment.	Butler (1965)
DEF (tech)	*Pteronarcys californica*	BSA	–	0.0021 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Delnav	*Gambusia affinis*	BSA	–	0.05 (K 3%)	a	Chemicals were dissolved in acetone, and tests were run in triplicate. Toxicity is given as average percent fish killed in 24 hr.	Lewallen (1959)
Delnav	*Pimephales promelas*	BSA	–	0.5 (O)	–	The degree of reaction to the cholinesterase-inhibiting insecticides is not only a function of time and concentration but also of chemical and biological species. This paper reports many analyses of brain cholinesterase activity which is expressed as percentage of normal. The data are reported as LT_{50} which was the time required for 0.5 ppm of the chemical to kill 50 percent of the fish. The LT_{50} for the fathead was 72 hours.	Weiss (1961)
Delnav (emulsible concentrate, 47 percent)	*Pimephales promelas*	BSA	–	12.0 (T4A)	a c d e	Soft water primarily was the test medium. TL_m's reported for 24, 48, and 96 hr. Acetone or alcohol used as solvent or carrier in most cases.	Pickering, et al (1962)
	Lepomis macrochirus			0.063 (T4A)			
	Lebistes reticulatus			0.57 (T4A)			
	Largemouth bass			0.076 (T4A)			
	Green sunfish			0.13 (T4A)			
Delnav (tech, 100 percent)	*Pimephales promelas*	BSA	–	10.0 (T4A)	a c d e	Comment same as above.	Pickering, et al (1962)
	Lepomis macrochirus			0.034 (T4A)			
	Carassius auratus			32.0 (T4A)			
	Lebistes reticulatus			0.21 (T4A)			
Delnav	*Chaoborus astictopus*	BSA	–	0.052 (T1A)	a	Toxicity value given is for the fourth instar larvae.	Hazeltine (1963)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Delnav	Bluegill	BSA	–	0.034 (T4A)	a	Assays were conducted in soft water at 25 C. Decrease in brain cholinesterase was measured in fish exposed to the toxicant.	Weiss (1964)
Delnav	*Carassius auratus* *Lepomis macrochirus*	BSCH	–	1.0 (O)* 1.0 (O)** * no response, 15 days **response, 15 days	a c d e	Toxicity was determined by measuring acetylcholinesterase activity in the brains of fish. Concentrations are given in ppb as either response or no response in 15 or 30 days.	Weiss and Gakstatter (1964)
Delrad	*Pithophora* spp *Lepomis macrochirus* *Micropterus salmoides*	FL	Ponds, Ala.	(O)	–	0.25 to 0.3 ppm of the chemical killed large amounts of *Pithophora* in ponds, but the effects were of short duration (1 to 3 weeks). As many as 4 applications of Delrad at a concentration of 0.3 ppm did not affect reproduction or production of bluegill in experimental ponds. As many as 3 applications of Delrad at the concentration of 0.3 ppm in bass brood ponds did not affect spawning of bass, hatching of eggs, or survival of fry and small fingerlings. The author states that "the minimal lethal dose" of this chemical for bluegill and large-mouth bass fingerlings is approximately 0.65 ppm. Microcrustaceans suffered approximately a 50-percent mortality when the concentration of the chemical reached 0.5 ppm. The addition of equal parts of Roccal (10%) to Delrad 50-S produced no better kill of *Pithophora* in ponds, and the effects were usually of longer duration (2 to 4 weeks).	Lawrence (1958)
Delrad 70	Channel catfish (fingerlings)	BSA	–	0.74 (K 25 hr A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Delrad 70	*Salvelinus fontinalis* *Salmo trutta* *Notemigonus crysoleucas*	FPCH	N.Y.	0.50 (S23)	a c d	Conventional farm ponds were used having an average surface area of 0.3 acre and a maximum depth of 7-9 ft. Toxicity (in ppm) to fish as maximum safe concentration (S) for 23 days was determined. Concentration of 0.5 ppm was required to control algae.	Eipper (1959)

Delrad 50S	*Salvelinus fontinalis*	FPCH	N.Y.	1.0 (S23)	a c d	Comment same as above.	Eipper (1959)
	Salmo gairdneri			1.0 (S23)			
	Catostomus commersoni			0.5 (S23)			
	Notemigonus crysoleucas			0.25-1.0 (S23)			
	Ictalurus punctatus			1.0 (S23)			
	Micropterus salmoides			1.0 (S23)			
	Lepomis macrochirus			0.5 (S23)			
Demeton	*Lepomis macrochirus*	BSA	–	0.1 (O)	a c d f	This paper reports the effect of insecticides in reducing the anticholinesterase in a fish brain within 2-8 hours. The inhibition of the enzyme was a function of the concentration of the insecticide, extent of exposure, and specific chemical nature of the compound.	Weiss (1959)
	Micropterus salmoides			0.1 (O)			
	Notemigonus crysoleucas			0.1 (O)			
	Carassius auratus			0.1 (O)			
Demeton	*Carassius auratus*	BSCH	–	1.0 (O)*	a c d e	Toxicity was determined by measuring acetycholinesterase activity in the brains of fish. Concentrations are given in ppb as either response or not response in 15 or 30 days.	Weiss and Gakstatter (1964)
	Lepomis macrochirus			1.0 (O)*			
	Notemigonus crysoleucas			1.0 (O)* * no response, 15 days			
Dermol	*Pandalus montagni*	BSA	–	148 (T2A)	a e	Experiments were conducted in tanks holding 10 liters of seawater at 15 C. It was shown that the toxicity of this solvent emulsifier decreased with time, due to evaporation of the solvent.	Portmann and Connor (1968)
	Crangon crangon			156 (T2A)			
	Carcinus maenas			435 (T2A)			
	Cardium edule edule			148 (T2A)			
Derris	*Lepomis macrochirus*	BSA	–	1.0 (K) 0.5 (K)	a d	The action of Derris root appeared to be somewhat faster in acid than alkaline waters. The derris employed in this experiment contained 5 percent rotenone.	Leonard (1938)
	Lepomis gibbosus			1.0 (K) 0.5 (K)			
	Catostomus commersonii			0.5 (K)			
	Notemigonus crysoleucas			0.5 (K)			
	Notropis cornutus frontalis			0.5 (K)			
	Eucalia inconstans			0.5 (K)			
	Umbra limi			0.5 (K)			
	Carassius auratus			0.5 (K)			

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Derris root (5% rotenone content)	*Ambloplites rupestris* *Huro salmoides* *Perca flavescens* *Salmo gairdneri* *Salvelinus fontinalis* *Salmo trutta* *Catostomus c. commersonii* *Lepomis gibbosus* *Semotilus astromaculatus* *Cristivomer namaycush* *Umbra limi* *Hyborhynchus notatus* *Eucalia inconstans* *Poecilichthys exilis* *Fundulus diaphanus menona* *Notemigonus crysoleucas auratus* *Entosphenus lamottenii*	FL	Mich.	0.35-0.56 (O)	a	The results of this experiment indicate that in certain trout waters which are overrun with warm water fish, trout and other cold water fish can withstand an application of derris root at the concentration given, while other fish (warm water fish) can be eliminated. Derris is much less effective in colder water. It is likely that a thermocline prevents the penetration of the poison to deeper water. No trout were killed in these experiments. All other fish listed showed some mortality.	Greenbank (1940)
Derris	Tendipedidae	FL	Colo.	1.0 (S)	a c d e	This is a study of lake bottom fauna. Oligochaeta were not affected. Collection data of bottom fauna are given.	Cushing and Olive (1957)
Detergents	*Pimephales promelas* (juveniles)	BSA	–	(S) 61-63 (T1-4A) (H) 39-44 (T1-4A)	a c d f	Syndets and soaps were of nearly equal toxicity in soft water (S) but syndets were approximately 40X more toxic than soap in hard water (H).	Henderson, et al (1959)
Dexon	Oyster	BCF	–	(O)	a	No effect on exposure to the chemical at 1.0 ppm.	Butler (1965)
Dexon	*Pteronarcys californica* (naiads)	BSA	–	0.024 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1966)

Dexon	*Penaeus aztecus*	L	–	(O)	a	Toxicant chemicals were evaluated in sea water at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality. No effect occurred at 1.0 ppm.	Butler (1965)
Dexon	*Cyprinodon variegatus* (juvenile)	BSA	–	(O)	a	Water temperature was 21 C. No effect was noticed on exposure to 1.0 ppm.	Butler (1965)
DFDT (DDT analogue)	Goldfish *Gambusia affinis* *Culex apicalis* (larvae)	BSA	–	0.9 (K) 0.175 (K) 0.0015 (K)	–	Experiments were run a maximum of 3 days. No other time data were reported.	Odum and Summerford (1946)
Diazinon	*Daphnia magna*	BSA	–	0.0043 (O)	a	The indicated concentration immobilized *Daphnia* in 50 hours.	Anderson (1960)
Diazinon	*Lepomis macrochirus* *Micropterus salmoides* *Notemigonus crysoleucas* *Carrasius auratus*	BSA	–	0.1 (O) 0.1 (O) 0.1 (O) 0.1 (O)	a c d f	This paper reports the effects of insecticides in reducing the anticholinesterase in a fish brain within 2-8 hours. The inhibition of the enzyme was a function of the concentration of the insecticide, extent of exposure, and specific chemical nature of the compound.	Weiss (1959)
Diazinon	*Micropterus salmoides* *Pimephales promelas*	BSA	–	0.5 (O) 0.5 (O)	–	The degree of reaction to the cholinesterase-inhibiting insecticides is not only a function of time and concentration, but also of chemical and biological species. This paper reports many analyses of brain cholinesterase activity which is expressed as percentage of normal. The data are reported as LT_{50} which was the time required for 0.5 ppm of the chemical to kill 50 percent of the fish. For bass the LT_{50} was 1 hr and for the fathead 80 min.	Weiss (1961)
Diazinon (EC2)	*Gambusia affinis*	FL	Ponds in Ill.	(O)	–	When applied at 0.3 pound per acre active ingredient, 100 percent mortality occurred in 1 day.	Mulla, et al (1963)
Diazinon	*Carassius auratus* *Lepomis macrochirus* *Notemigonus crysoleucus*	BSCH	–	1.0 (O)* 1.0 (O)* 1.0 (C)* *no response, 15 days	a c d e	Toxicity was determined by measuring acetylcholinesterase activity in the brains of fish. Concentrations are given in ppb as either response or not response in 15 or 30 days.	Weiss (1964)
Diazinon	*Pteronarcys* sp (nymphs)	BSA	–	0.025 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Diazinon, Tech.	Rainbow trout Bluegill	BSA	–	0.090 (T4A) 0.022 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)

Chemical	Organism	Bioassay or Field Study$^{(1)}$	Field Location$^{(2)}$	Toxicity, Active Ingredient, ppm$^{(3)}$	Experimental Variables Controlled or Noted$^{(4)}$	Comments	Reference (Year)
Diazinon	*Salmo gairdnerii*	BSA	–	0.170 (T2A)	a	This paper reports acute toxicity of a number of compounds, and discusses sub-acute mortality as well. Effects on reproduction and behavior are also discussed. Data presented as EC_{50}.	Cope (1966)
	Lepomis macrochirus			0.030 (T2A)			
	Pteronarcys californicus			0.074 (T2A)			
	Daphnia pulex			0.0009 (T2A)			
	Simocephalus serrulatus			0.002 (T2A)			
Diazinon	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	–	0.4 (O)	a	Stones heavily populated with wild larvae were placed in troughs of running water containing the toxicant. When the larvae became detached from the rocks and floated away, they were assumed to have undergone lethal intoxication. The larvae were exposed to the toxicant for 5 minutes, then in clean water for 24 hours. At that time the number detached amounted to 13 percent.	Jamnback and Frempong-Boadu (1966)
Diazinon	*Simocephalus serrulatus*	BSA	–	0.0018 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 48 hr. Data cited are for 60 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
	Daphnia pulex			0.00090 (SB)			
	Daphnia carinata		–	0.0008 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed a varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	
Diazinon	*Leiostromus xanthurus*	BCFH	–	0.001 (O)	a	At a concentration of .001 ppm, the following percent acetylcholinesterase activity as compared to controls was found: *L. xanthurus* – 100 *C. variegatus* – 74	Butler and Johnson (1967)
	Cyprinodon variegatus			0.001 (O)			
Diazinon	*Pteronarcys californica* (naiads)	BSA	–	0.025 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Dibrom	*Gambusia affinis*	BSA	–	0.03 (K 3%)	a	Chemicals were dissolved in acetone, and tests were run in triplicate. Toxicity is given as average percent fish killed in 24 hr.	Lewallen (1959)
Dibrom	*Salmo gairdnerii* (one wk. old	BSA	–	1.0 (K 23%) 10.0 (K 100%)	a e	Results are averages of triplicate tests. Toxicity is reported as percent mortality (K %).	Lewallen and Wilder (1962)
	(one mo. old feeding fry)			1.0 (K 0%) 10.0 (K 100%)			

Dibrom	*Salmo gairdneri*	BSA	—	80 (T 18 hr)	a	The experiment was conducted at 55 F. Fish were 2-3 in. long.	Cope (1963)
Dibrom (tech)	*Salmo gairdneri*	BSA	—	70 (T1A)	a	Comment same as above.	Cope (1963)
Dibrom (tech)	*Procambarus clarki*	BSA	—	4.0 (T3A)	a c d o	There was no detectable difference in toxicity to male or female crawfish.	Muncy and Oliver (1963)
Dibrom (tech)	Bluegill	BSA	—	0.180 (T4A)	—	The values reported are given as LC_{50}.	Cope (1965)
Dibrom	Oyster	BCF	—	0.1 (SB4) 1.0 (SB4)	a	Sea water was employed in this experiment.	Butler (1966)
Dibrom	*Simocephalus serrulatus* *Daphnia pulex*	BSA	—	0.0011 (SB) 0.00035 (SB)	—	Concentration reported is for immobilization. Time for immobilization was 48 hr. Data cited are for 60 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
Dibrom	*Leiostromus xanthurus* *Cyprinodon variegatus* *Mugil cephalus*	BCFCH	—	0.05 (O) 0.05 (O) 0.001 (O)	a	At a concentration of 0.05 or 0.001 ppm, the following percent acetylcholinesterase activity as compared to controls was found: *L. xanthurus* — 10 *C. variegatus* — 79 *M. cephalus* — 76	Butler and Johnson (1967)
Dicamba (Banvel D)	*Oncorhynchus kisutch* *Salmo gairdneri*	BSA	—	151 (T1A) 120 (T2A) 320 (O)	a c d	The active ingredient of Dicamba is 2-methoxy-3, 6-dichlorobenzoic acid (dimethylamine salt). Tests were conducted in glass jars holding 15 liters of water. Concentrations of 320 ppm produced no mortalities in rainbow trout.	Bond, et al (1965)
Dicamba (Banvel D)	Rainbow trout Bluegill	BSA	—	35.0 (T2A) 130.0 (T2A)	—	Data are given as LC_{50}.	Bohmont (1967)
Dicapthon	*Chaoborus astictopus*	BSA	—	0.0057 (T1A)	a	Toxicity value given is for the first instar larvae.	Hazeltine (1963)
Dichlobenil	*Lepomis macrochirus*	BSA	—	17.0 (T2A) L 30.0 (T2A) G	a c d e f	Toxicity data for 24 and 48 hours are presented for liquid (L) and granular (G) formulations. Various commercial formulations were tested. The liquid formulations were almost invariably more toxic than the granular ones.	Hughes and Davis (1965)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Dichlobenil	*Salmo gairdnerii*	BSA	–	22.0 (T2A)	a	This paper reports acute toxicity of a number of compounds, and discusses sub-acute mortality as well. Effects on reproduction and behavior are also discussed. Data presented as EC_{50}.	Cope (1966)
	Lepomis macrochirus			20.0 (T2A)			
	Pteronarcys californicus			8.4 (T2A)			
	Daphnia pulex			3.7 (T2A)			
	Simocephalus serrulatus			5.8 (T2A)			
Dichlobenil (Casoran)	*Daphnia magna*	BSA	–	9.8 (8.8-10.7) (O)	a c d i q	Toxicity, in terms of median immobilization concentration (IC_{50}), is presented for *Daphnia*; median lethal concentration (LC_{50}) values for rainbow trout and bluegill are reported.	Crosby and Tucker (1966)
	Rainbow trout			22 (O)			
	Bluegill			20 (O)			
Dichlobenil	*Lepomis macrochirus* (eggs)	L	–	20 (S), 10 (NTE)	–	Fertilized fish eggs of indicated species were placed in 1 liter of test solution and allowed to hatch. Toxicity data are presented as concentration in ppm/number of days survival. Maximum length of test was 8 days. No food was was added. Small bluegill were tested to find the highest concentration of chemical which did not cause death in 12 days (S).	Hiltibran (1967)
	L. cyanellus (eggs)			25 (NTE)			
	Micropterus dolomieui (eggs)			25 (NTE)			
	Erimyzon sucetta (eggs)			25 (NTE)			
	L. macrochirus (fry)			20 (S)			
Dichlobenil	*Pteronarcys californica*	BSA	–	0.007 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Dichlone (Phygon)	*Daphnia magna*	BSA	--	0.014 (O)	a c d i q	Toxicity, in terms of median immobilization concentration (IC_{50}), is presented for *Daphnia;* medium lethal concentration (LC_{50}) values for bluegill are reported.	Crosby and Tucker (1966)
	Bluegill			0.04 (O)			
Dichlorvos	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	–	0.4 (O)	a	Stones heavily populated with wild larvae were placed in troughs of running water containing the toxicant. When the larvae became detached from the rocks and floated away, they were assumed to have undergone lethal intoxication. The larvae were exposed to the toxicant for 5 minutes, then in clean water for 24 hours. At that time the number detached amounted to 41 percent.	Jamnback and Frempong-Boadu (1966)
Dichlorvos	*Pteronarcys californica* (naiads)	BSA	–	0.001 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1966)

Diethanol rosinamine D acetate	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ms)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – T Ms – T So – T (3), PT (21) Cv – T (7), PT Gp – T Np – T	Palmer and Maloney (1955)
DIDT (DDT analogue)	Goldfish *Gambusia affinis* *Culex apicalis* (larvae)	BSA	–	0.175 (K) 0.025 (K) 0.003 (K)	–	Experiments were run a maximum of 3 days. No other time data were reported.	Odum and Sumerford (1946)
Dieldrin	*Carassius auratus* *Lepomis macrochirus*	BSA	–	4.0 (K) 2 hr	–	The toxicity threshold for the 2 species was 0.031 ppm. Water taken from rice field that had been treated with 0.1 pound of Dieldrin per acre, 10 to 20 days previously, killed fish unless diluted 1/2 with pond water.	Gray (1950)
Dieldrin (hexachloroepoxy-octahydrodi-methanonapthalene, 25 percent)	Lymnaeid snails	BSA	–	(O)	a	Each test container, 500-ml beaker, was filled with ditch water. 100% mortality occurred in concentrations of 1:400,000 and greater.	Batte, et al (1951)
Dieldrin (granules)	*Simulium* sp (larvae)	FR	Streams, S. C.	0.04 (O)	–	Dieldrin at a 0.04 lb/acre rate of application controlled blackfly larvae for up to 4 weeks. Data are presented as percent larval detachment for this period of time.	Davis, et al (1957)
Dieldrin	*Artemia salina*	BSA	–	1.172 (L 1	a i	Rock salt was used in rearing all cultures employed in bioassay work. The optimum salt concentration was 3.5%.	Tarpley (1958)
Dieldrin	Fish Crustacea fiddler crabs, etc. Mollusks snails oysters, etc.	FO (salt marsh)	Fla.	(O)	–	Two thousand acres of marsh were treated for sandfly control at rate of 1 lb/acre. Fish reacted to the chemical within a few minutes after treatment (list of fish names given). An estimated 20-30 tons of fish of about 30 species died. Crustaceans, mollusks seemed to be unharmed. Fish repopulation began after the 4th week and was climactic at the 10th week.	Harrington and Bidlingmayer (1958)
Dieldrin	Fathead minnow Bluegill Goldfish Guppy	BSA	–	0.016 (T4A) 0.0079 (T4A) 0.037 (T4A) 0.022 (T4A)	a	It was the authors opinion that pH, alkalinity and hardness, within the usual range in natural waters, had little effect on the toxic effect of the compounds studied. The values given are from Henderson, Pickering, and Tarzwell, "The Relative Toxicity of Ten Chlorinated Hydrocarbon Insecticides to Four Species of Fish". It is interesting that the different tables from the above book (as reported in this paper) report widely different values for the same compounds. This experiment was performed in soft water.	Tarzwell (1959)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Dieldrin	Fathead minnow	BSA	–	0.016 (T4A)	a	It was the authors opinion that pH, alkalinity and hardness, within the usual range in natural waters, had little effect on on the toxic effect of the compounds studied. The values given are from Henderson, Pickering, and Tarzwell, "The Relative Toxicity of Ten Chlorinated Hydrocarbon Insecticides to Four Species of Fish". It is interesting that the different tables from the book (as reported in this paper) report widely different values for the same compounds. This experiment was performed in soft water.	Tarzwell (1959)
Dieldrin (dust)	*Tilapia melanopleura*	FLCH	Tanganyika	1 lb (3.3% K) 5 lb (6.6% K - 3 wks) 10 lb (66.6% K - 3 wks)	–	Trial periods were for 20 weeks. Sublethal effects such as impaired breeding, retarded growth, or altered taste were not detected. Dosages are given as lb/acre of surface water.	Webb and Shute (1959)
Dieldrin (granules)	*Tilapia melanopleura*			1 lb (0% K)	–	Comment same as above.	Webb and Shute (1959)
Dieldrin 50	Channel catfish (fingerlings)	BSA	–	2.5 (K 25 hr A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Dieldrin	*Pimephales promelas*	BSA	–	0.01 (T4A)	a d e f	Concentrations were based on percent active ingredient.	Henderson, et al (1959)
	Lepomis macrochirus			0.01 (T4A)			
	Carassius auratus			0.04 (T4A)			
	Lebistes reticulatus			0.02 (T4A)			
Dieldrin	*Pimephales promelas*	BSA	–	0.018 (T4A)	a b c d f	Dilution water was usually soft although some studies were conducted with hard water.	Henderson, et al (1959)
	Lepomis macrochirus			0.0088 (T4A)			
	Carassius auratus			0.041 (T4A)			
	Lebistes reticulatus			0.025 (T4A)			
Dieldrin	*Pimephales promelas*	BSA	–	0.016 (T4A)	a	Bioassay investigations of the new insecticides indicate that in general the organic phosphorus compounds are not as toxic to fish as are the chlorinated hydrocarbons. The toxicity of most of these materials was not significantly influenced by water quality. Therefore it is to be expected that the toxicity of these materials will not differ significantly in different streams.	Tarzwell (1959)
	Lepomis macrochirus			0.0079 (T4A)			

Dieldrin	*Pimephales promelas* *Lepomis macrochirus*	BSA	Cincinnati, O.	0.1 to 5.0 (T4A) 0.0056-0.042 (T4A)	a c d e f p	Toxicity of run-off water from areas treated with Dieldrin was evaluated. Three different Dieldrin formulations were used: powder, emulsion, and acetone solution. The acetone formulation was generally the most toxic.	Tarzwell and Henderson (1960)
Dieldrin	*Daphnia magna*	BSA	–	0.33 (O)	a	The indicated concentration immobilized *Daphnia* in 50 hours.	Anderson (1960)
Dieldrin	*Oncorhynchus kisutch* *Oncorhynchus tshawytscha* *Salmo gairdnerii* *Gasterosteus aculeatus*	BSA	–	10.8 (T4A) 6.1 (T4A) 9.9 (T4A) 15.3 (T4A)	a c d e	Chemical dissolved in acetone. TL_m expressed in ppb.	Katz (1961)
Dieldrin	*Salmo gairdneri*	BSA	–	0.0355 (T1A) 0.0233 (T2A) 0.0233 (T4A)	a c d f g	Hatchery artesian well water was employed for this experiment.	Webb (1961)
Dieldrin	*Gammarus lacustris lacustris*	BSA	–	(O)	a e p	The mortality might have been partially due to the susceptibility of the organism to higher temperatures, toxicity from extended exposure to copper electrodes (used to shock the organism to determine death), or the increase of CO_2. Results were expressed as LT_{50}; for example, at 0.5 ppm, 50 percent of the shrimp were killed in 74 (±7) min.	McDonald (1962)
Dieldrin	*Ophicephalus punctatus* *Heteropneustes fossilis* *Barbus stigma* *Trichogaster fasciatus*	BSA	–	4000-8000 (K <4 hr) 2000-8000 (K <9 hr) 4000 (K <3 hr) 2000-4000 (K <4 hr)	a	The dosage to produce toxic symptoms varied with each species. At the very low dosage, these insecticides did not produce observable changes, but at the higher dosage changes were pronounced.	Mathur (1963)
Dieldrin (EC 1.5)	*Gambusia affinis* *Rana catesbeiana* (tadpoles)	FL	Cal.	0.5 (O)	a c	Mixed populations of the indicated test species contained in cages were exposed to various insecticidal chemicals applied as dilute sprays to ponds 1/16 acre in size. The indicated toxicant concentration is in lb/acre, and resulted in a 100 percent mortality for the tadpoles in 24 hr.	Mulla (1963)
Dieldrin	*Gambusia affinis affinis*	BSA	–	0.016 to .50	a	The lower value is for fish that had never been exposed to the toxicant, and the higher value was obtained with fish that had been exposed to a sublethal dose in the past. Apparently such an exposure produces a resistance that can be retained when they are later placed in clean water.	Boyd and Ferguson (1964)
Dieldrin	*Lepomis gibbosus*	BSA & CH	–	0.0067 (T4A)	a c d e	Other medium tolerance limits were: 0.0155 ppm – 24 hours 0.012 ppm – 48 hours 0.0075 ppm – 72 hours. Chronic exposure to 0.00168 ppm for the period of 12 weeks affected the oxygen consumption and the cruising speed ability.	Cairns and Scheier (1964)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Dieldrin	*Notemigonus crysoleucas* *Lepomis macrochirus* *L. cyanellus*	BSA	–	(B) 0.025 (T 1.5) (A) 0.90 (T 1.5) (B) 0.025 (T 1.5) (A) 0.900 (T 1.5) (B) 0.033 (T 1.5) (A) 1.25 (T 1.5)	a c f	Chemical was dissolved in acetone. Final concentration of acetone was <2 ml/l. Data shows TL_m in ppb for insecticide-resistant and insecticide non-resistant strains of the test fish.	Ferguson, et al (1964)
Dieldrin (tech, 100 percent active in acetone)	*Pteronarcys californica* (naiad) *Acroneuria pacifica*	BSA	–	0.03900 (T4A) 0.02400 (T4A)	c d e f	*A. pacifica* was much more sensitive to chlorinated hydrocarbons and to organic phosphate insecticides that *P. californica.*	Jensen and Gaufin (1964)
Dieldrin	*Gammarus lacustris*	BSA	–	0.70 (T4A)	a e	Emulsible concentrates were prepared from technical grade insecticides with acetone as the solvent. Symptoms prior to death were observed and recorded on graphs.	Nebeker and Gaufin (1964)
Dieldrin	Bluegill	BSA	–	0.0079 (T4A)	a	Assays were conducted in soft water at 25 C. Decrease in brain cholinesterase was measured in fish exposed to the toxicant.	Weiss (1964)
Dieldrin (tech)	Rainbow trout Bluegill	BSA	–	0.013 (T4A) 0.0026 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
Dieldrin	Bluegill	BSA	–	16 (T4A) 18 (T4A) 14.5 (T4A) 9.3 (T4A) 7.1 (T4A)	a	These experiments were performed to demonstrate that at increased temperatures the toxic effect of most chemicals is increased. For the toxicant concentrations listed, the temperatures were respectively, 45, 55, 65, 75, and 85 F. Data on the effect of time as well as temperature was also reported. The experimental animals all were approximately one grain in weight.	Cope (1965)
Dieldrin	*Palaemonetas kadiakensis*	BSA	–	(N) 50.0 (T1-1/2A) (TB) 135.0 (T1-1/2A)	a c f	Test organisms were collected from 2 locations, Twin Bayou (TB), Sunflower Co., Miss. (agricultural area) and Noxubee National Wildlife Refuge (N), Noxubee Co., Miss. (non-agricultural area) and evaluated in laboratory bioassays. The Twin Bayou shrimp were more resistant.	Ferguson, et al (1965)
Dieldrin	*Gambusia affinis* *Ictalurus melas*	BSA	–	0.001-0.025 (T3A) 0.003-0.028 (T3A)	a c d e	Test fish were collected from 8 different locations of the Mississippi River. The 3-day TL_m values were made to determine if a resistance gradient existed. The data indicated that there was none.	Ferguson, et al (1965)

Dieldrin	*Pteronarcys californica* *Acroneuria pacifica* *Ephemerella grandis* *Daphnia magna* *Gammarus lacustris*	BSA	–	0.04 (T4A) 0.02 (T4A) 0.008 (T4A) 0.3 (T 50 hr A) 0.7 (T4A)	a	Unspecified chemical characteristics of assay water were determined by standard methods. General comments were made concerning "standardized" conditions, use of "soft" water, and use of emulsifying agents. Additional data are presented.	Gaufin, et al (1965)
Dieldrin	*Acroneuria pacifica* *Ephemerella grandis* *Gammarus lacustris* *Pteronarchys californica*	BSA	–	0.024 (T4A) 0.008 (T4A) 0.7 (T4A) 0.039 (T4A)	a c	Additional TL_m data are given.	Gaufin, et al (1965)
Dieldrin	*Carassius carassius*	BSCH	–	0.1 (SB-2 hrs) 0.075 (SB-4 hrs)	–	Data given on chemical residue found in tissue computed from C^{14} activity was: 37.2 mg/g in blood 10.5 mg/g in muscle.	Weiss (1965)
Dieldrin	*Poecilia reticulata*	BSA	–	0.021 (T4A)	a i	Light was controlled in this experiment. All tests were conducted in soft, synthetic dilution water.	Cairns and Loos (1966)
Dieldrin	*Salmo gairdneri* *Lepomis macrochirus* *Ictalurus punctatus* *Pteronarcys californicus* *Baetis* sp *Daphnia pulex* *Simocephalus serrulatus*	BSA	–	0.005 (T2A) 0.006 (T2A) 0.025 (T2A) 0.001 (T2A) 0.064 (T2A) 0.250 (T2A) 0.250 (T2A)	a	This paper reports acute toxicity of a number of compounds, and discusses sub-acute ntoxicity as well. Effects on reproduction and behavior are also discussed. Data presented as EC_{50}.	Cope (1966)
Dieldrin	*Salmo gairdnerii*	BCFA	–	0.016 (K1)	–	The gills, muscles, and livers of the fish were examined for concentrations of the chemical. The trout tended to accumulate this compound in all tissues studied.	Holden (1966)
Dieldrin	*Acroneuria pacifica* *Pteronarcys californica*	BSA & CFCH	–	0.024 (T4A) 0.0002 (T30A) 0.039 (T4A) 0.002 (T30CH)	a c d e	Additional data are presented.	Jensen and Gaufin (1966)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Dieldrin	*Platalea leucorodia* *Haematopus ostralegus* *Sterna sandvicensis* *Sterna Hirundo* *Larus ridibundus* *Somateria mollissima* *Tadorna tadorna*	FO	Netherlands	(O)	–	The results of this study show that birds of prey and fish-eating birds found dead in the Netherlands accumulated large amounts of different chlorinated hydrocarbon insecticides. In most cases the liver had the highest concentration of toxicant, ranging from a trace to 9.5 ppm of endrin. Birds feeding on predominantly crustacea, molluscs, and fish contained significant amounts.	Koeman and van Genderen (1966)
Dieldrin	*Buteo buteo* *Accipiter gentilis* *Accipiter nisus* *Falco tinnunculus* *Tyto alba* *Strix aluco* *Osio otus* *Falco pereginus*	FO	Netherlands	(O)	–	The results of this study show that birds of prey and fish-eating birds found dead in the Netherlands accumulated large amounts of different chlorinated hydrocarbon insecticides. In most cases the liver had the highest concentration of toxicant, ranging from 0.4 to 44.0 ppm. Most chlorinated hydrocarbons tended to accumulate in the fat depots of the body. In instances where mesenterial fat was analyzed the concentration of toxicant was found to be as high as 17.0 ppm.	Koeman and van Genderen (1966)
Dieldrin	*Daphnia magna* *Daphnia carinata* *Simocephalus serrulatus* *Daphnia pulex*	BSA	–	0.740 (SB) 0.250 (SB) 0.240 (SB) 0.250 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
Dieldrin (20% active)	*Tubifex* spp *Limnodrilus* spp	BSA	–	6-71 (T4A)	a c e	Toxicity is reported as the mean lethal dose (LD_{50}) for 24, 48, and 96 hours.	Whitten and Goodnight (1966)

Dieldrin	*Mya arenaria* *Crassostrea virginica* *Corbicula manillensis* *Mercenaria mercenaria* *Rangia cuneata*	BCFCH	–	(O)	–	Results are recorded as a range of uptake of the chemical by 5 species of aquatic mollusks. An uptake or concentration of 700-1800X resulted.	Butler (1967)
Dieldrin	*Poecilia reticulata*	BCH	–	0.0018 (O) 0.0056 (O) 0.01 (O)	a	The three levels of toxicant reported are near "the estimated biologically safe concentration" for acute exposure of guppies to dieldrin. The period of exposure was fourteen months, during which time, conditions of "food, water, temperature, and photo period" were controlled. At the higher concentration, there was suggestive evidence that long-term exposure to Dieldrin had a deleterious effect on the reproductive process.	Cairns, et al (1967)
Dieldrin	Oyster	FE	Galveston Bay, Texas	(O)	–	Oysters from the area were found to contain <0.01 to 0.01 ppm.	Casper (1967)
Dieldrin	Goldfish	BSA & CH	–	50 mμg/ml (K)	–	Test fish were conditioned to alkyl benzene sulfonate (4 μg/ml, or sodium lauryl sulfate (4 μg/ml), for various periods of time, then exposed to pesticides. Chronic exposure to the detergent increased the toxicity of the pesticide.	Dugan (1967)
Dieldrin-C^{14}	*Lepomis macrochirus* *Carassius auratus*	BCFCH	–	(O)	a	Fish were treated with carbon-labeled insecticides (0.03 ppm) from 5 to 19 hr and uptake rates were determined. They were placed in recovery tanks for up to 32 days. Whole body samples were then made. It was found that of the dieldrin absorbed, >90% was eliminated from the fish after 2 weeks.	Gakstatter and Weiss (1967)
Dieldrin	*Lebistes reticulatus*	BSA	–	(O)	a c e i	The median lethal concentration for a 2 hour exposure to Dieldrin for guppies was approximately 0.05 ppm. The median concentration for Harlequin fish (*Rasbora heteromorpha*) and trout (*Salmo* sp) was approximately 0.01 ppm. This short exposure to dieldrin for guppies up to the median lethal concentration had no harmful effects on the reproduction of surviving guppies.	Hubble and Reiff (1967)
Dieldrin	*Salmo* spp *Lebistes reticulatus* *Rasbora heteromorpha*	BSA & CH	–	(O)	a c d e f i	The median lethal concentration for a 2 hour exposure to Dieldrin for trout was approximately 0.01 ppm. Reproductive capacity of surviving trout could not be determined. The median lethal concentration for a 2 hour exposure to Dieldrin for guppies was approximately 0.05 ppm. Reproductive capacity of surviving guppies was apparently unaffected. The median lethal concentration for a 2 hour exposure to Dieldrin for Harlequin fish was approximately 0.01 ppm. Reproductive capacity of the surviving fish could not be determined.	Hubble and Reiff (1967)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Dieldrin	*Esox lucius*	FR	River Nene, Eng.	(O)	–	Higher concentrations were found in larger fish, indicating that they had been exposed to the pesticides for a longer time. Tissue extracts from the pike were analyzed for organochlorine pesticide residues by gas liquid chromatography. The values for large pike were: 0.24 ppm muscle 28.0 ppm fat	Mawdesley-Thomas and Leahy (1967)
Dieldrin	*Navicula seminulum var. Hustedtii*	BSA	–	12.8 (T5A)	a	This diatom species survived concentrations of Dieldrin considerably greater than those reported for fish and aquatic invertebrates. Fish feeding on these algae could receive lethal amounts of Dieldrin.	Cairns (1968)
Dieldrin	*Limnephilus rhombicus* *Sialis* sp *Gammarus* sp *Salvelinus fontinalis* *Semotilus atromarulatus* *Cottus bairdi*		Knights Creek, Wisc.	(O)	–	Pesticide usage in an orchard did not significantly contaminate the aquatic environment of this creek adjacent to the treatment as determined by residue analysis.	Moubry, et al (1968)
Dieldrin	*Alosa pseudoharengus* *Aplodinotus grunniens* *Coregonus artedii* *Lota lota*	BSA	–	(O)	–	The study showed that the levels of chlorinated hydrocarbon pesticide residues in fish meals and oils were, with the exception of the oil sample taken from the Lake Michigan alewife, below the regulatory tolerances established by the Food and Drug Directorate of Canada (1965) for certain foods intended for human consumption. Pesticide levels were interpreted as being representative for each species.	Dugal (1968)
Dieldrin	*Poecilia reticulata*	BSA	–	(O)	a	The paper describes a method for continuously producing a supply of an aqueous solution of Dieldrin by passing water at a constant rate through a column of sand coated with the insecticide. The concentration of HEOD, the active ingredient of Dieldrin, was nearly constant over a period of several months, but the toxicity of the water declined steeply during the first few weeks until a relatively stable level was attained.	Chadwick and Kiigemagi (1968)
Dieldrin	*Pteronarcys californica* (naiads) *Pteronarcella badia* (naiads) *Claasenia sabulosa* (naiads)	BSA	–	0.0005 (T4A) 0.0005 (T4A) 0.00058 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)

Difolatan	Oyster	BCF	–	0.034 (O)	a	The value reported is a 96-hour EC_{50} (decreased shell growth).	Butler (1965)
	Fundulus similus (juvenile)	BSA	–	0.032 (O)	a	Water temperature was 20 C. The figure reported is a 48-hr EC_{50}.	
Difolatan [N-(1, 1, 2, 2-tetrachlorethylthio)-4-cyclohexane-1,2-dicarboximide]	*Brachydanio rerio*	BSA	–	1 (O)	a	At 1 ppm all larvae were killed within 48 min. The TL_{50} was 34 min. LC_{50} was 0.21 ppm.	Abedi and Turton (1968)
Difolatan	*Pteronarcys californica* (naiads)	BSA	–	0.0004 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Dilan	Channel catfish (fingerlings)	BSA	–	0.5 (K 25 hr A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Dilan	*Gambusia affinis*	BSA	–	0.5 (L1)* 0.4 (L1)** * Resistant fish **Nonresistant fish	a	This paper deals with the resistance of mosquito fish to chlorinated hydrocarbon compounds. Resistant fish were not always less sensitive to these chemicals.	Boyd and Ferguson (1964)
Dimecron	*Cyprinus carpio*	BSA	–	51.5 (T2A)	a c d e f p	The test animals were conditioned for 48 hours prior to use.	Sreenivasan and Swaminathan (1967)
Dimethoate	*Anopheles quadrimaculatus* *Aedes aegypti*	BSA	–	3.5 (O) 4.0 (O)	–	4th instar larvae of mosquitos were used in this bioassay. At the indicated concentrations, the following mortalities occurred: *Anopheles quadrimaculatus* 79% *Aedes aegypti* 29% Adsorption was determined by use of P^{32} labeled dimethoate.	Schmidt and Weidhaas (1961)
Dimethoate	*Pteronarcys* sp (nymphs)	BSA	–	0.043 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Dimethoate (tech)	Bluegill	BSA	–	6.0 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
Dimethoate	*Prosimulium* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	–	4.0 (O)	a	Stones heavily populated with wild larvae were placed in troughs of running water containing the toxicant. When the larvae became detached from the rocks and floated away, they were assumed to have undergone lethal intoxication. The larvae were exposed to the toxicant for 5 minutes, then in clean water for 24 hours. At that time the number detached amounted to 4 percent.	Jamnback and Frempong-Boadu (1966)
Dimethoate	*Pteronarcys californica* (naiads)	BSA	–	0.043 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Dimetnrin	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	–	0.4 (O)	a	Stones heavily populated with wild larvae were placed in troughs of running water containing the toxicant. When the larvae became detached from the rocks and floated away, they were assumed to have undergone lethal intoxication. The larvae were exposed to the toxicant for 5 minutes, then in clean water for 24 hours. At that time the number detached amounted to 89 percent.	Jamnback and Frempong-Boadu (1966)
Dimethyl urea	*Salmo gairdnerii*	BSA	–	975 (T1A) 925 (T2A) 100 (T1A)* 100 (T2A)* *with adjuvant	a e	Most of the weed-killer formulations in this study consisted of more than one substance, i.e., oils, emulsifiers, stabilizers, and other adjuvants.	Alabaster (1956)
Dimetilan	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	–	4.0 (O)	a	Stones heavily populated with with wild larvae were placed in troughs of running water containing the toxicant. When the larvae became detached from the rocks and floated away, they were assumed to have undergone lethal intoxication. The larvae were exposed to the toxicant for 5 minutes, then in clean water for 24 hours. At that time the number detached amounted to 2 percent.	Jamnback and Frempong-Boadu (1966)
Dimeton	*Pimephales promelas*	BSA	–	0.5 (O)	–	The degree of reaction to the cholinesterase-inhibiting insecticides is not only a function of time and concentration, but also of chemical and biological species. This paper reports many analyses of brain cholinesterase activity which is expressed as percentage of normal. The data are reported as LT_{50} which was the time required for 0.5 ppm of the chemical to kill 50 percent of the fish. The LT_{50} for the fathead was 72 hr.	Weiss (1961)
Dipterex	Rainbow trout Eastern brook trout	BCFA	–	1-10 (K 0%)	a	Spring water (46 F) was used. The flow rate was 10 GPM. The chemical was added by continuous drip dispenser. 0.02 ppm for 180 hr showed toxic effects, but no kill.	Hoffman (1957)
Dipterex	Fathead minnow	BSA	–	51 (T4A)	a	It was the authors opinion that pH, alkalinity and hardness, within the usual range in natural waters, had little effect on the toxic effect of the compounds studied. The values given are from Henderson, Pickering, and Tarzwell, "The Relative Toxicity of Ten Chlorinated Hydrocarbon Insecticides to Four Species of Fish". It is interesting that the different tables from the above book (as reported in this paper) report widely different values for the same compounds. This experiment was performed in hard water.	Tarzwell (1959)
Dipterex	*Pimephales promelas*	BSA	–	180 (T4A)	a d e f	Concentrations were based on percent active ingredient.	Henderson, et al (1959)

Dipterex	*Pimephales promelas*	BSA	–	180 (T4A)	a	Bioassay investigations of the new insecticides indicate that in general the organic phosphorus compounds are not as toxic to fish as are the chlorinated hydrocarbons. The toxicity of most of these materials was not significantly influenced by water quality. Therefore it is to be expected that the toxicity of these materials will not differ significantly in different streams.	Tarzwell (1959)
Dipterex	*Protococcus* sp *Chlorella* sp *Dunaliella euchlora* *Phaeodactylum tricornutum* *Monochrysis lutheri*	BSA	–	1000 (K) 500 (K) 500 (K) 500 (K) 100 (K)	a	This paper concerns the growth of pure cultures of marine plankton in the presence of toxicants. Results were expressed as the ratio of optical density of growth in the presence of toxicants to optical density in the basal medium with no added toxicants.	Ukeles (1962)
Dipterex	*Chaoborus astictopus*	BSA	–	0.60 (T1A)	a	Toxicity value given is for the fourth instar larvae.	Hazeltine (1963)
Dipterex	Bluegill	BSA	–	3.8 (T4A)	a	Assays were conducted in soft water at 25 C. Decrease in brain cholinesterase was measured in fish exposed to the toxicant.	Weiss (1964)
Dipterex	*Daphnia magna*	BSA	–	0.00012 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
Dipterex (99%)	*Pimephales promelas*	BSA	–	180 (T4A)	a c d e f	Tests were performed in both hard and soft water. Additional tolerance limit values are given.	Henderson and Pickering (1958)
Dipterex	*Daphnia carinata* *Simocephalus serrulatus* *Daphnia pulex*	BSA	–	0.00025 (SB) 0.00070 (SB) 0.00018 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
Diquat	*Onchorynchus tshawytscha*	BSA	–	29.5 (T1A) 28.5 (T2A)	a c d e	Concentrations were based on percent active ingredient.	Bond, et al (1960)
Diquat	*Salmo gairdneri*	BSA	–	(O)	a	No mortality was noted with concentrations of 10,000 mg/1 at 55 F for 100 hr. Fish were 2-3 in. long.	Cope (1963)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Diquat (1:1'-ethylene-2:2'-depyridylium dibromide)		BSA	—		a	Experiments were conducted in standing water. Results were rated on a scale of 0 to 10, 0 standing for no toxic effect and 10 signifying a complete kill. Evaluation was based on visual observation of the plant response at weekly intervals for 4 weeks.	Frank, et al (1961)
	Elodea canadensis			5 (O) 100 (O)		Injury rating of 8.5. Injury rating of 9.0.	
	Potamogeton nodosus			5 (O) 100 (O)		Injury rating of 7.5. Injury rating of 9.0.	
	Potamogeton pectinatus			5 (O) 100 (O)		Injury rating of 8.8. Injury rating of 9.4.	
Diquat	*Lepomis macrochirus*	BSA	—	140 (T4A) H 72 (T4) S	a c e	Bioassay methods in Standard Methods for examination of water was used. Both hard (H) and soft (S) water were used. TL_m values for 24 and 48 hr are also presented.	Surber and Pickering (1962)
	Pimephales promelas			130 (T4A) H 14 (T4) S			
	Micropterus salmoides			78 (T4A) S			
Diquat	*Micropterus salmoides* (fry)	BSA	—	1.0 (SB3)	a c d e f p	At least 90 percent of the fry survived for a period of 72 hours at the concentration listed.	Jones (1965)
	Ictalurus punctatus (fry)			10.0 (SB3)			
	Lepomis macrochirus (fry)			4.0 (SB3)			
Diquat	*Lemna minor* *Spirodela polyrhyza* *Wolffia columbiana*	FL	Fla.	(O)	—	Common duckweed and watermeal in small ponds can be controlled with diquat at rates as low as 0.25 ppmw, but rates greater than 0.5 ppmw are required for control in ponds infested with watermeal.	Blackburn and Weldon (1965)
Diquat	*Spirodela polyrhyza*	BSA	—	(O)	a	0.01 ppm caused 80% chlorosis in 7 days.	Blackburn and Weldon (1965)
	Lemna minor					0.01 ppm caused 90% chlorosis in 7 days.	
	Wolffiella floridana					0.01 ppm caused 72% chlorosis in 7 days.	
	Azolla caroliniana					0.01 ppm caused 50% chlorosis in 7 days.	
	Wolffia columbiana					0.01 ppm caused 3% chlorosis in 7 days.	
						Light intensity was kept at 500 foot-candles for 14 hours per day. Light has been shown to increase the rate of kill with diquat. Test containers were plastic petri dishes.	

Diquat (1,1'-ethylene-2,2'-dipyridylium dibromide)	Plankton Oligochaeta Chironomids	FL	Fls.	0.5 (O)	–	Water samples from ponds taken at 3 and 11 days after application showed concentrations of diquat at 0.25 ppm and 0.001 ppm, respectively. No diquat was present after 16 days. Plankton appeared to be adversely affected by 0.5 ppm of diquat, but recovered rapidly. *Oligochaeta* showed a subtle chronic sensitivity to diquat.	Tatum and Blackburn (1965)
Diquat	*Lepomis macrochirus*	BSA	–	9-10 (L10)	–	Toxicity to fish was determined as the threshold concentration (LD10) in 96 hr at 75 F (65 F for trout). Herbicidal evaluations are also presented.	Lawrence, et al (1965)
	Micropterus salmoides			10 (L10)	–		
	Pimephales promelas			10 (L10)	–		
	Ictalurus punctatus			10 (L10)	–		
	Salmo gairdneri			5 (L10)	–		
Diquat	Oyster	BCF	–	(O)	a	No effect on exposure to the chemical at 1.0 ppm.	Butler (1965)
	Fundulus similus (juvenile)	BSA	–	(O)	a	Water temperature was 19 C. No effect was noticed on exposure to 1.0 ppm.	
Diquat	*Penaeus setiferus*	L	–	(O)	a	Toxicant chemicals were evaluated in seawater at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality. No effect occurred at 1.0 ppm.	Butler (1965)
Diquat	*Crassostrea virginica*	BCFA & BSA	–	1.0 (NTE)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Concl which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
	Penaeus setiferus			1.0 (NTE)			
	Fundulus similis			1.0 (NTE)			
	Phytoplankton			45% (O)			

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Diquat	Ephemeroptera Caenidae Odonata Coenagrionidae Hemiptera Hebridae Mesoveliidae Gerridae Veliidae Pleidae Belostomaladae Corixidae Coleoptera Halipidae Dytiscidae Diptera Chironomidae Amphipoda Talitridae Basommatophora Planorbidae Physidae Copepoda Ostracoda *Eucalia inconstans* *Salvelinus fontinalis*	FL	Price Co., Wisc.	(O)	—	An application of 1.0 ppm of Diquat was made to control a nuisance weed, *Elodea canadensis*, in a pond. The effect of this treatment on aquatic insects and related animals was monitored. At 1.0 ppm, Diquat appeared to be harmless to the aquatic fauna, but caused sharp changes in the numbers of most arthropods and mollusks by destroying their habitats. Organisms affected to some degree are recorded in the organisms column.	Hilsenhoff (1966)
Diquat	*Salmo gairdneri* *Lepomis macrochirus*	BSA	—	20.000 (T2A) 19.000 (T2A)	a	This paper reports acute toxicity of a number of compounds, and discusses sub-acute toxicity as well. Effects on reproduction and behavior are also discussed. Data presented as EC_{50}.	Cope (1966)
Diquat	*Daphnia magna*	BSA	—	7.1 (6.3-8.0) (O)	a c d i q	Toxicity, in terms of median immobilization concentration (IC_{50}), is presented.	Crosby and Tucker (1966)

Diquat	*Potamogeton crispus*	FL	Ponds, Central Illinois	0.5 (K)	–	Liquid formulations containing two pounds of the Diquat cation per gallon as the dibromide salt were used in all experiments. Most applications were based on the Diquat cation content in ppm, but some rates were expressed as the volume of herbicide per gallon of water, e.g., the 25.0 rate of application resulted in a kill by a foliage application of 25 ml of chemical diluted to 1 gallon with water. The paper states that recently *Scirpus acutus* was killed by a foliage application containing 10 ml of Diquat and 3 ml of X-77, a non-ionic wetting agent, diluted to 1 gallon with water.	Hiltibran (1967)
	P. foliosus			0.5 (K)			
	P. pectinatus			0.5 (K)			
	P. pusillus			0.5 (K)			
	Myriophyllum exalbescens			0.5 (K)			
	Ranunculus trichophyllus			0.5 (K)			
	Elodea canadensis			1.0 (K)			
	Ceratophyllium demersum			1.0 (K)			
	Najas flexilis			1.0 (K)			
	Cabomba caroliniana			4.0 (NTE)			
	Typha latifolia			25.0 (O)			
	T. angustifolia			25.0 (O)			
	Justicia americana			25.0 (O)			
	J. repens var. glabrescens			25.0 (O)			
	Sagittaria latifolia			25.0 (O)			
	Scirpus acutus			(O)			
Diquat	Salmon	BSA	–	28.5 (T2A)	–	Data are given as LC_{50}.	Bohmont (1967)
Diquat	*Lepomis macrochirus*	BSA	–	35 (T4A)	a c d f i l m n p	The herbicide showed an acute toxicity to *Cladocera*. At 3 ppm the *Cladocera* population was reduced to a level of 102 as opposed to a maximum in the control of 150.	Gilderhus (1967)
	Carassius auratus			35 (T4A)			
	Esox lucius			16 (T4A)			
	Salmo gairdnerii			11.2 (T4A)			
	Stizostedion vitreum vitreum			2.1 (T4A)			
	Daphnia pulex			3 (K8)			
	Cladocera			(O)			
Diquat	*Lepomis macrochirus*	BSCH	–	(O)	a c d f i m p	*Elodea canadensis* was used as an indicator of herbicidal activity and to provide a nearly natural habitat in artificial ponds. Fingerling and adult bluegills were used in this experiment. The pools were treated with 1 and 3 ppm of Diquat at various frequencies. No fish kill occurred. After 24 weeks no residues of the chemical were found in the bluegills at a treatment rate of 3 ppm in one study. However, another experiment indicated a residue of 1.1 ppm in bluegills.	Gilderhus (1967)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Diquat	*Lepomis macrochirus* (eggs) *Micropterus dolomieui* (eggs) *Erimyzon sucetta* (eggs) *L. macrochirus* (fry)	L	–	2.5/3 (O) 2.5/1 (O), 1.3/4 (O) 2.5/2 (O), 1.3/2 (O) 10 (S)	–	Fertilized fish eggs of indicated species were placed in 1 liter of test solution and allowed to hatch. Toxicity data are presented as concentration in ppm/number of days survival. Maximum length of test was 8 days. No food was added. Small bluegill were tested to find the highest concentration of chemical which did not cause death in 12 days (S).	Hiltibran (1967)
Di-Syston	*Pimephales promelas* *Lepomis macrochirus*	BSA	–	3.7 (T4A) 0.064 (T4A)	a d e f	Concentrations were based on percent active ingredient.	Henderson, et al (1959)
Di-Syston	*Pimephales promelas* *Lepomis macrochirus*	BSA	–	3.7 (T4A) 0.064 (T4A)	a	Bioassay investigations of the new insecticides indicate that in general the organic phosphorus compounds are not as toxic to fish as are the chlorinated hydrocarbons. The toxicity of most of these materials was not significantly influenced by water quality. Therefore it is to be expected that the toxicity of these materials will not differ significantly in different streams.	Tarzwell (1959)
Di-Syston	*Micropterus salmoides* *Pimephales promelas*	BSA	–	0.5 (O) 0.5 (O)	–	The degree of reaction to the cholinesterase-inhibiting insecticides is not only a function of time and concentration, but also of chemical and biological species. This paper reports many analyses of brain cholinesterase activity which is expressed as percentage of normal. The data are reported as LT_{50} which was the time required for 0.5 ppm of the chemical to kill 50 percent of the fish. For bass the LT_{50} was 24 hr and for the fathead 72 hr.	Weiss (1961)
Di-syston (tech, 90 percent)	*Carassius auratus* *Lebistes reticulatus*	BSA	–	7.2 (T4A) 0.28 (T4A)	a c d e	Soft water primarily was the test medium. TL_m's reported for 24, 48, and 96 hr. Acetone or alcohol used as solvent or carrier in most cases.	Pickering, et al (1962)
Di-syston, (emulsible concentrate, 20 percent)	*Lepomis macrochirus*	BSA	–	0.082 (T4A)	a c d e	Soft water primarily was the test medium. TL_m's reported for 24, 48, and 96 hr. Acetone or alcohol used as solvent or carrier in most cases.	Pickering, et al (1962)
Di-Syston (tech, 89 percent active in acetone)	*Pteronarcys californica* (naiad) *Acroneuria pacifica* (naiad)	BSA	–	0.0285 (T4A) 0.0082 (T4A)	c d e f	*A pacifica* was much more sensitive to chlorinated hydrocarbons and to organic phosphate insecticides than *P. californica.*	Jensen and Gaufin (1964)

Di-Syston	*Gammarus lacustris*	BSA	–	0.24 (T4A)	a e	Emulsible concentrates were prepared from technical grade insecticides with acetone as the solvent. Symptoms prior to death were observed and recorded on graphs.	Nebeker and Gaufin (1964)
Di-Syston	Bluegill	BSA	–	0.063 (T4A)	a	Assays were conducted in soft water at 25 C. Decrease in brain cholinesterase was measured in fish exposed to the toxicant.	Weiss (1964)
Di-Syston	Bluegill	BSCH	–	1.0 (O)* *response, 15 days	a c d e	Toxicity was determined by measuring acetylcholinesterase activity in the brains of fish. Concentrations are given in ppb as either response or not response in 15 or 30 days.	Weiss and Gakstatter (1964)
Di-Syston	*Pteronarcys californica*	BSA	–	0.03 (T4A)	a	Unspecified chemical characteristics of assay water were determined by standard methods. General comments were made concerning "standardized" conditions, use of "soft" water, and use of emulsifying agents. Additional data are presented.	Gaufin, et al (1965)
	Acroneuria pacifica			0.008 (T4A)			
	Ephemerella grandis			0.08 (T4A)			
	Gammarus lacustris			0.2 (T4A)			
	Bluegill sunfish			0.07 (T4A)			
	Fathead minnow			4.1 (T4A)			
Disulfoton	*Pteronarcys californica* (naiads)	BSA	–	0.005 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Dowacide A	*Protococcus* sp	BSA	–	100 (NG)	a	This paper concerns the growth of pure cultures on marine plankton in the presence of toxicants. Results were expressed as the ratio of optical density of growth in the presence of toxicants to optical density in the basal medium with no added toxicants. NG = no growth, but the organisms were viable.	Ukeles (1962)
	Chlorella sp			100 (NG)			
	Dunaliella euchlora			100 (NG)			
	Phaeodactylum tricornutum			100 (K)			
	Monochrysis lutheri			50 (K)			
Diuron	*Oncorhynchus kisutch*	BSA	–	33 (T1A) 16 (T2A)	a c d e	Concentrations were based on percent active ingredient. Low Low toxicity occurred with *M. salmoides* in the solubility range of this compound.	Bond, et al (1960)
	Micropterus salmoides			(O)			
Diuron	*Protococcus* sp	L	–	0.004 (K)	a	This paper concerns the growth of pure cultures of marine plankton in the presence of toxicants. Results were expressed as the ratio of optical density of growth in the presence of toxicants to optical density in the basal medium with no added toxicants. NG = no growth, but the organisms were viable.	Ukeles (1962)
	Chlorella sp			0.04 (NG)			
	Dunaliella euchlora			0.004 (NG)			
	Phaeodactylum tricoruntum			0.004 (K)			
	Monochrysis lutheri			0.00002 (K)			
Diuron	*Penaeus aztecus*	L	–	(O)	a	Toxicant chemicals were evaluated in sea water at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality. No effect occurred at 1.0 ppm.	Butler (1965)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Diuron	*Crassostrea virginica* *Penaeus aztecus* *Mugil cephalus* Phytoplankton	BCFA & BSA	–	1.8 (O) 1.0 (NTE) 6.3 (T2A) 87% (O)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
Diuron (tech)	Bluegill	BSA	–	4.0 (T4A)	a	This is an estimated LC_{50} value at temperatures from 55 to 75 F.	Cope (1965)
Diuron-TCA (3 lb/gal)	*Lepomis macrochirus*	BSA	–	5.7 (T4A)	–	Laboratory bioassays indicated that toxicity of the different formulations evaluated in this varied greatly with the fish used. Mortality data are expressed as EC_{10}, EC_{50}, etc.	Walker (1965)
Diuron (80 percent, WP)	*Ictalurus nebulosis* *Lepomis macrochirus*	BSA	–	11.0 (T4A) 25.0 (T4A)	–	Comment same as above.	Walker (1965)
Diuron	*Salmo gairdneri* *Lepomis macrochirus* *Daphnia pulex* *Simocephalus serrulatus*	BSA	–	4.300 (T2A) 7.400 (T2A) 1.400 (T2A) 2.000 (T2A)	a	This paper reports acute toxicity of a number of compounds, and discusses sub-acute mortality as well. Effects on reproduction and behavior are also discussed. Data presented as EC_{50}.	Cope (1966)
Diuron	*Daphnia magna* Bluegill	BSA	–	47 (41.6-53.1) (O) 7.4 (O)	a c d i q	Toxicity, in terms of median immobilization concentration (IC_{50}), is presented for *Daphnia*; median lethal concentration for (LC_{50}) values for bluegill are reported.	Crosby and Tucker (1966)
Diuron	*Simocephalus serrulatus* *Daphnia pulex*	BSA	–	2.00 (SB) 1.40 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during during the assay period.	Sanders and Cope (1966)
Diuron (Karmex)	Salmon Bluegill	BSA	–	16.0 (T2A) 74.0 (T2A)	–	Data are given as LC_{50}.	Bohmont (1967)
Diuron (tech)	*Pteronarcys californica* (naiads)	BSA	–	0.0012 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)

Dowco 139 (25 percent EC)	*Gambusia affinis*	FL	Ponds—Bakersfield, Cal.	(O)	a c	At 0.1 lb/acre, 2 percent mortality occurred in 24 hours. The experiments were conducted in cages placed in the ponds.	Mulla and Isaak (1961)
Dowicide 31 (chloro-2-phenyl phenol, tech)	Lymnaeid snails	BSA	—	(O)	—	Each test container (500-ml beaker) was filled with ditch water. 100% mortality occurred at 1:200,000 and greater.	Batte, et al (1951)
Dowicide F (sodium 2,3,4,6-tetrachlorophenate, 80 percent)	Lymnaeid snails	BSA	—	(O)	—	Each test container (500-ml beaker) was filled with ditch water. 100% mortality occurred in concentrations of 1:600,000 and greater.	Batte, et al (1951)
Dowpon (2,2-dichloropropionic acid)	*Richardsonius balteatus hydroflox*	BSA	—	444 (T1A) 412 (T2A) 395 (T4A)	a c d e f	Results given were in soft water.	Webb (1961)
Dowpon	*Typha latifolia* *Panicum hemitomum*	FL	Fla.	(O)	—	At 51.0 and 17.0 lb/acre, 95 percent control of cattail was obtained and 3-5 percent control of *P. hemitomum.*	Copeland and Woods (1959)
Dowpon	*Oncorhynchus kisutch* *Micropterus salmoides*	BSA & CF	—	340 (T1) 340 (T2)	a c d e	Concentrations were based on percent active ingredient. In constant flow experiments, no bass survived 48 hours' exposure at 1000 ppm.	Bond, et al (1960)
2-(2,4DP) (dimethylamine)	*Lepomis macrochirus*	BSA	—	165 (T2A)	a e	The various salts of the chemicals showed wide variations in toxicity.	Hughes and Davis (1963)
2-(2,4-DP) (butoxyethanol ester)	*Lepomis macrochirus*	BSA	—	1.1 (T2A)	a e	Comment same as above.	Hughes and Davis (1963)
2-(2,4DP) (isooctyl ester)	*Lepomis macrochirus*	BSA	—	16 (T2A)	a e	Comment same as above.	Hughes and Davis (1963)
2,4-DP (ester)	*Lepomis macrochirus* *Erimyzon sucetta* *L. macrochirus* (fry)	L	—	10 (NTE) 1.5 (NTE) 20 (S)	—	Fertilized fish eggs of indicated species were placed in 1 liter of test solution and allowed to hatch. Toxicity data are presented as concentration in ppm/number of days survival. Maximum length of test was 8 days. No food was added. Small bluegill were tested to find the highest concentration of chemical which did not cause death in 12 days (S).	Hiltibran (1967)
DPT (DDT analogue)	Goldfish *Gambusia affinis* *Culex apicalis* (larvae)	BSA	—	10.0 (K) 2.0 (K) 0.1 (K)	—	Experiments were run a maximum of 3 days. No other time data were reported.	Odum and Sumerford (1946)
Drummer (pine)	Guppy	BSA	—	100 (K1)	a	Those fish that survived at lower concentrations were still very active several days after they had been taken out and placed in fresh water.	Anonymous (1964)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Dursban	*Notemigonus crysoleucas*	BSA	–	1.0 (T<1A)	e f	Fish used in the experiment were obtained from two sources, Mississippi Delta and State College pond. The fish obtained from the State College pond had not been exposed to insecticides. The fish obtained from the Mississippi Delta were known to be contaminated by cotton crop insecticides. Higher tolerance of Delta populations was evident in longer survival to 1.0 ppm Dursban.	Ferguson, et al. (1966)
	Gambusia affinis			1.0 (T<1A)			
	Lepomis cyanellus			1.0 (T<1A)			
Dursban	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	–	0.4 (O)	a	Stones heavily populated with wild larvae were placed in troughs of running water containing the toxicant. When the larvae became detached from the rocks and floated away, they were assumed to have undergone lethal intoxication. The larvae were exposed to the toxicant for 5 minutes, then in clean water for 24 hours. At that time the number detached amounted to 32 percent.	Jamnback and Frempong-Boadu (1966)
Dursban	*Leiostromus xanthurus* *Callinectes sapidus*	BCFCH	–	0.001 (O)	a	At a concentration of .001 ppm, the following percent acetylcholinesterase activity as compared to controls was found: *L. xanthurus* – 38	Butler and Johnson (1967)
Dursban	*Callinectes sapidus*	BCFCH	–	0.010 (K)	a	Little or no information was given about test procedures and further tests.	Butler and Johnson (1967)
Dursban	*Pteronarcys californica* (naiads)	BSA	–	0.01 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Dursban	*Pteronarcys californica* (naiads)	BSA	–	0.010 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
	Pteronarcella badia (naiads)			0.0038 (T4A)			
	Claasenia sabulosa (naiads)			0.0057 (T4A)			
DVP-iodine	*Photococcus* sp	BSA	–	100 (O)*	a	This paper concerns the growth of pure cultures of marine plankton in the presence of toxicants. Results were expressed as the ratio of optical density of growth in the presence of toxicants to optical density in the basal medium with no added toxicants. NG = no growth, but the organisms were viable.	Ukeles (1962)
	Chlorella sp			100 (O)*			
	Dunaliella euchlora			50 (NG)			
	Phaeodactylum tricornutum			50 (NG)			
	Monochrysis lutheri			100 (K) *obvious, but inhibited growth.			

Dylox	*Gambusia affinis*	BSA	–	0.5 (K 0%)	a	Chemicals were dissolved in acetone, and tests were run in triplicate. Toxicity is given as average percent fish killed in 24 hr.	Lewallen (1959)
Dylox	*Salmo gairdnerii* (one wk old sac fry)	BSA	–	1.0 (K 0%) 10.0 (K 0%)	a e	Results are averages of triplicate tests. Toxicity is reported as percent mortality (K %).	Lewallen and Wilder (1962)
	(one mo old feeding fry)			1.0 (K 0%) 10.0 (K 0%)			
Dylox (Dipterex), (tech, 99 percent)	*Pimephales promelas*	BSA	–	110 (T4A)	a c d e	Soft water primarily was the test medium. TL_m's reported for 24, 48, and 96 hr. Acetone or alcohol used as solvent or carrier in most cases.	Pickering, et al (1962)
	Lepomis macrochirus			3.8 (T4A)			
	Carassius auratus			100 (T4A)			
	Lebistes reticulatus			7.2 (T4A)			
Dylox (tech, 89 percent active in acetone)	*Pteronarcys californica* (naiad)	BSA	–	0.0690 (T4A)	c d e f	*A. pacifica* was much more sensitive to chlorinated hydrocarbons and to organic phosphate insecticides than *P. californica*.	Jensen and Gaufin (1964)
	Acroneuria pacifica (naiad)			0.0165 (T4A)			
Dylox	*Gammarus lacustris*	BSA	–	0.050 (T4A)	a e	Emulsible concentrates were prepared from technical grade insecticides with acetone as the solvent. Symptoms prior to death were observed and recorded on graphs.	Nebeker and Gaufin (1964)
Dylox	*Cyprinodon variegatus* (juvenile)	BSA	–	(O)	a	Water temperature was 13 C. No effect was noticed on exposure to 1.0 ppm.	Butler (1965)
Dylox, (tech)	Bluegill	BSA	–	0.260 (T4A)	a	This is an estimated LC_{50} value at temperatures from 55 to 75 F.	Cope (1965)
Dylox, (tech)	Rainbow trout	BSA	–	1.40 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
	Bluegill			0.260 (T4A)			
Dylox	*Pteronarcys* sp (nymphs)	BSA	–	0.035 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}	Cope (1965)
Dylox	*Pteronarcys californica*	BSA	–	0.07 (T4A)	a	Unspecified chemical characteristics of assay water were determined by standard methods. General comments were made concerning "standardized" conditions, use of "soft" water, and use of emulsifying agents. Additional data are presented.	Gaufin, et al (1965)
	Acroneuria pacifica			0.02 (T4A)			
	Ephemerella grandis			0.14 (T4A)			
	Gammarus lacustris			0.050 (T4A)			
	Fathead			180.0 (T4A)			

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Dylox	*Acroneuria pacifica*	BSA	–	0.017 (T4A)	a c	Additional TL_m data are given.	Gaufin, et al (1965)
	Ephemerella grandis			0.14 (T4A)			
	Gammarus lacustris			0.05 (T4A)			
	Pteronarcys californica			0.07 (T4A)			
Dylox (99% active in water)	*Hexagenia*	BSA	–	0.91 (T1A)	a e	Dissolved oxygen was measured before and after assay. Assays were conducted in Mississippi River water.	Carlson (1966)
	Hydropsyche (larva)			0.017 (T1A)			
	Bluegill			12.0 (T1A)			
Dylox	*Carassius auratus* *Lebistes reticulatus*	BCFA	–	0.4% (O)	a	The fish were fed on a diet to which the indicated amount of the chemical was added. During a 90-day period female goldfish showed no difference from the controls, while male fish showed a marked decrease in growth rate – but this does not necessarily demonstrate that the chemical inhibited growth in the males. Reproduction was apparently not affected. Guppies under Dylox seemed to grow and reproduce normally.	Clemens, et al (1966)
Dymid (WP)	Bluegill	BSA?	–	75.0 (T4A)	a	This is an estimated LC_{50} value at temperatures from 55 to 75 F.	Cope (1965)
	Rainbow trout			97.0 (T4A)			
EDB	*Lepomis macrochirus*	BSA	–	18 (T2A)	a c o	The response of bluegill and bass fingerlings to nine agricultural chemicals as determined by bioassay using river water is presented in this report. Bluegills were more tolerant of the chemicals tested than bass.	Davis and Hardcastle (1959)
	Micropterus salmoides			15 (T2A)			
EN 18133 (50 percent EC)	*Gambusia affinis*	FL	Ponds – Bakersfield, Cal.	0.1 (K1) 0.4 (K1)	a c	Toxicity values indicate application rates in lb/acre. The experiments were conducted in cages placed in the ponds.	Mulla and Isaak (1961)
Endosulfan EC2	*Micropterus salmoides* *Cyprinus carpio*	BSA	–	0.01 (O) 0.025 (K1) 0.005 (K 5 hr) 0.01 (K 3 hr) 0.02 (O)	a e	At 0.01 ppm, 50 percent mortality occurred in 1 day. For bass: Experiments were carried out in fiber glass tubs filled with well water. Fish weights ranged from 2 to 6 pounds. At 0.02 ppm, 94 percent mortality occurred in 3 hr. For carp: Fish weights averaged 217 grams.	Mulla, et al (1967)
Endosulfan EC2	*Micropterus salmoides*	FL	Chino Fishery bass pond, Cal.	0.05 (K1) 0.10 (K1)	a	The activity of Endosulfan when applied at 0.10 ppm lasted about 3 or 4 days. On the fifth day of treatment, only low mortality of the fish occurred in the treated pond.	
	Cyprinus carpio			0.05 (K1) 0.10 (K1)			
Endosulfan	*Pteronarcys californica* (naiads)	BSA	–	0.00023 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)

Endothal	*Semotilus atromaculatus*	BSA	–	1,600 to 3,200 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
Endothal	*Onchorynchus tshawytscha* *Micropterus salmoides*	BSA, CF, and FL	–	155 (T1A) 136 (T2A) 200 (T1A) 200 (T2A)	a c d e	Concentrations were based on percent active ingredient. In 96 hours of exposure in the constant-flow apparatus, no largemouth bass mortalities were observed at 135 ppm, which was the highest concentration tested. In experimental field studies, Endothal controlled *Potamogeton pusillus* at about 0.3 ppm with no loss of largemouth bass or bluegills which were present in the pond.	Bond, et al (1960)
Endothal (pellets)	Bushy pondweed Pondweed Coontail	FL	Lakes in Fla.	(O) (O) (O)	–	Concentrations of 0.5 to 2.0 ppm showed the best results in a variety of lakes, and in one lake 16.0 ppm was required to control bushy pondweed. 1.0 ppm controlled pondweed and coontail.	Phillippy (1961)
Endothal [3,6-endoxohexahydrophthalic acid (endothal), di-N,N-dimethylcocoamine salt]		BSA	–		a	Experiments were conducted in standing water. Results were rated on a scale of 0 to 10, 0 standing for no toxic effect and 10 signifying a complete kill. Evaluation was based on visual observation of the plant response at weekly intervals for 4 weeks.	Frank, et al (1961)
	Elodea canadensis			5 (O) 100 (O)		Injury rating of 8.5. Injury rating of 9.0.	
	Potamogeton nodosus			5 (O) 100 (K 4 wk)		Injury rating of 9.1.	
	Potamogeton pectinatus			5 (O) 100 (K 4 wk)		Injury rating of 9.8.	
Endothal and Silvex	*Lepomis macrochirus*	BSA	–	400 (T2A) L 600 (T2A) G	a c d e g	Toxicity data for 24 and 48 hours are presented for liquid (L) and granular (G) formulations. Various commercial formulations were tested. The liquid formulations were almost invariably more toxic than the granular ones.	Hughes and Davis (1965)
Endothal	*Lepomis macrochirus*	BSA	–	280 (T2A) L 280 (T2A) G	a c d e g	Comment same as above.	Hughes and Davis (1965)
Endothal (liquid)	*Micropterus salmoides* (fry)	BSA	–	10 (SB3)	a c d e f p	At least 90 percent of the fry survived for a period of 72 hours at the concentration listed.	Jones (1965)
	Ictalurus punctatus (fry)			100 (SB3)			
	Lepomis macrochirus (fry)			50 (SB3)			

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Endothal (granular)	*Micropterus salmoides* (fry)	BSA	–	2.0 (SB3)	a c d e f p	At least 90 percent of the fry survived for a period of 72 hours at the concentration listed.	Jones (1965)
	Ictalurus punctatus (fry)			50.0 (SB3)			
	Lepomis macrochirus (fry)			2.0 (SB3)			
Endothal	*Lepomis macrochirus*	BSA	–	(H) 160 (T4A)	a c e	Bioassay method in Standard Methods for examination of water was used. Both hard (H) and soft (S) water were used. TL_m values for 24 and 48 hr are also presented.	Surber and Pickering (1962)
	Pimephales promelas			(H) 610 (T4A) (S) 320 (T4A)			
	Micropterus salmoides			(H) 200 (T4A)			
Endothal (dipotassium)	*Lepomis macrochirus*	BSA	–	428 (T1A)	–	The bioassay methods employed in this experiment were not given in the paper but it was stated that the same procedures were employed as in previous work.	Davis and Hughes (1963)
Endothall	*Daphnia magna*	BSA	–	46 (36-57) (O)	a c d i q	Toxicity, in terms of median immobilization concentration (IC_{50}), is presented.	Crosby and Tucker (1966)
Endothal	Salmon	BSA	–	136 (T2A)	–	Data are given as LC_{50}.	Bohmont (1967)
Endothal	*Lepomis macrochirus* (eggs)	L	–	10 (NTE)	–	Fertilized fish eggs of indicated species were placed in 1 liter of test solution and allowed to hatch. Toxicity data are presented as concentration in ppm/number of days survival. Maximum length of test was 8 days. No food was added. Small bluegill were tested to find the highest concentration of chemical which did not cause death in 12 days (S).	Hiltibran (1967)
	L. cyanellus (eggs)			10 (NTE)			
	Micropterus dolomieui (eggs)			10 (NTE)			
	Erimyzon sucetta (eggs)			10 (NTE)			
	L. macrochirus (fry)			50 (S)			

Endrin	*Carassius auratus* *Cyprinus carpio*	FL	Japan	(O)	—	Four days after spraying at an application rate of 1 lb/acre, all fish placed in pond were dead after 8 hours of exposure. Endrin toxicity may persist in paddy fields as long as 1 month.	Iyatomi, et al (1958)
Endrin	*Carassius auratus* *Channa argus* (eggs & larvae) *Cyprinus carpio* (adult) (adult) (eggs & larvae) *Moina macrocopa*	BSCH	—	0.00 (T1CH) 0.002 (T[illegible]CH) 0.0065-100 (T1CH) 0.003-0.42 (T1CH) 0.002-0.14 (T2CH) 0.046-19.9 (T1CH) 3.2 (T1CH) 0.056 (T2CH)	a	Endrin became less toxic as temperature was lowered. Eggs and larvae of fishes were more resistant than adults, and the granular form of Endrin persisted longer than dust form.	Iyatomi, et al (1958)
Endrin	Fathead minnow Bluegill Goldfish Guppy	BSA	—	0.001 (T4A) 0.00060 (T4A) 0.0019 (T4A) 0.0015 (T4A)	a	It was the authors opinion that pH, alkalinity and hardness, within the usual range in natural waters, had little effect on the toxic effect of the compounds studied. The values given are from Henderson, Pickering, and Tarzwell, "The Relative Toxicity of Ten Chlorinated Hydrocarbon Insecticides to Four Species of Fish". It is interesting that the different tables from the above book (as reported in this paper) report widely different values for the same compounds. This experiment was performed in soft water.	Tarzwell (1959)
Endrin	Fathead minnow	BSA	—	0.0013 (T4A)	a	Comment same as above except that this experiment was performed in hard water.	Tarzwell (1959)
Endrin	*Daphnia magna*	BSA	—	0.352 (O)	a	The indicated concentration immobilized *Daphnia* in 50 hours.	Anderson (1960)
Endrin	*Pimephales promelas* *Lepomis macrochirus* *Carassius auratus* *Lebistes reticulatus*	BSA	—	0.001 (T4A) 0.0006 (T4A) 0.002 (T4A) 0.002 (T4A)	a d e f	Concentrations were based on percent active ingredient.	Henderson, et al (1959)
Endrin (75%)	*Pimephales promelas*	BSA	—	0.0032 (T4A)	a b c d f	Dilution water was usually soft although some studies were conducted with hard water.	Henderson, et al (1959)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Endrin (91%)	*Pimephales promelas*	BSA	–	0.0014 (T4A)	a b c d f	Dilution water was usually soft although some studies were conducted with hard water.	Henderson, et al (1959)
	Lepomis macrochirus			0.00066 (T4A)			
	Carassius auratus			0.0021 (T4A)			
	Lebistes reticulatus			0.0016 (T4A)			
Endrin (19.5%)	*Pimephales promelas*	BSA	–	0.0038 (T4A)	a b c d f	Comment same as above.	Henderson, et al (1959)
	Lepomis macrochirus			0.0037 (T4A)			
Endrin	*Pimephales promelas*	BSA	–	0.0010 (T4A)	a	Bioassay investigations of the new insecticides indicate that in general the organic phosphorus compounds are not as toxic to fish as are the chlorinated hydrocarbons. The toxicity of most of these materials was not significantly influenced by water quality. Therefore it is to be expected that the toxicity of these materials will not differ significantly in different streams.	Tarzwell (1959)
Endrin	Live cars: *Pimephales promelas* *Ictalurus melas* *Lepomis cyanellus* Fish kill: *Perca flavescens* *Lepomis gibbosus* *L. macrochirus* *Pomixis nigromaculatus* *Cyprinus carpio*	FL	Pond	(O)	a c d	A beet field located adjacent to the study pond was treated with Endrin at the rate of 6 ounces of active ingredient per acre. Many fish were found dead after application. Live cars of the fish listed were placed in the pond to assess the residual toxic effects of Endrin. No mortality occurred in the live cars for 4 days, but the fish did accumulate Endrin in concentrations up to 1.0 ppm. The acute toxicity of Endrin appears to be less under these field conditions than in the laboratory.	Bridges (1961)
Endrin	*Oncorhynchus kisutch*	BSA	–	0.51 (T4A)	a c d e	Chemical dissolved in acetone. TL_m expressed in ppb.	Katz (1961)
	Oncorhynchus tshawytscha			1.2 (T4A)			
	Salmo gairdnerii			0.58 (T4A)			
	Gasterosteus aculeatus			0.44 (T4A)			

Endrin	*Salmo gairdnerii*	BSA	–	0.90 (T4A)	a c d e	River water was diluent. TL_m concentration is given in ppb.	Katz (1961)
	Oncorhynchus tshawytscha			0.92 (T4A)			
	Oncorhynchus kisutch			0.27 (T4A)			
	Lepomis macrochirus			0.60 (T4A)			
	Gambusia affinis			0.75 (T4A) 20 C 8.25 (T4A) 3 C 0.33 (T4A) 25 C			
	Lebistes reticulatus			0.90 (T4A)			
	Gasterosteus aculeatus			1.65 (T4A) Salinity 1.65 pp thousand.			
Endrin	*Gammarus lacustris lacustris*	BSA	–	(O)	a e p	The mortality might have been partially due to the susceptibility of the organism to higher temperatures, toxicity from extended exposure to copper electrodes (used to shock the organism to determine death), or the increase of CO_2. Results were expressed as LT_{50}; for example, at 0.5 ppm, 50 percent of the shrimp were killed in 27 (±1) min.	McDonald (1962)
Endrin	*Pimephales notatus*	BCFA	–	0.00047 (T4A)	a c d f	Chronic toxicity was also studied, as well as the effect of the toxicant on swimming and oxygen consumption. In the chronic study, bluntnose minnows survived for extended periods in 0.0001 ppm. Experiment on guppies was discontinued because they succumbed to a kidney disorder.	Mount (1962)
	Lebistes reticulatus Adult ♂ Adult ♀ Adult ♂ Adult ♀			 0.0009 (T8A) 0.0009 (T10.6A) 0.00075 (T15A) 0.00075 (T15.5A)			
Endrin (tech)	*Lepomis macrochirus*	BSA	–	0.4 (T1A) 0.4 (T1A)	a	The experiment was conducted at 75 F. Fish weight was 0.4 g. The experiment was conducted at 75 F. Fish weight was 0.6 g.	Cope (1963)
Endrin EC 1.6	*Gambusia affinis* *Rana catesbeiana* (tadpoles)	FL	Cal.	0.5 (O)	a c	Mixed populations of the indicated test species contained in cages were exposed to various insecticidal chemicals applied as dilute sprays to ponds 1/16 acre in size. The indicated toxicant concentration is in lb/acre, and resulted in a 100 percent mortality for the fish, and a 100 percent mortality for the tadpoles in 24 hr.	Mulla (1963)
Endrin (tech)	*Procambarus clarki*	BSA	–	0.3 (T3A)	a c d o	There was no detectable difference in toxicity to male or female crawfish.	Muncy and Oliver (1963)
Endrin	*Gambusia affinis affinis*	BSA	–	0.001 to 0.12	a	The lower value is for fish that had never been exposed to the toxicant, and the higher value was obtained with fish that had been exposed to a sublethal dose in the past. Apparently such an exposure produces a resistance that can be retained when they are later placed in clean water.	Boyd and Ferguson (1964)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Endrin	*Notemigonus crysoleucas* *Lepomis macrochirus* *L. cyanellus*	BSA	–	(B) 0.003 (T1.5) (A) 0.310 (T1.5) (B) 0.0015 (T1.5) (A) 0.300 (T1.5) (B) 0.0034 (T1.5) (A) 0.160 (T1.5)	a c f	Chemical was dissolved in acetone. Final concentration of acetone was <2 ml/l. Data shows TL_m in ppb for insecticide-resistant and insecticide non-resistant strains of the test fish.	Ferguson, et al (1964)
Endrin (technical, 100 percent active in acetone)	*Pteronarcys californica* (naiad) *Acroneuria pacifica* (naiad)	BSA	–	0.00240 (T4A) 0.00039 (T4A)	c d e f	*A. pacifica* was much more sensitive to chlorinated hydrocarbons and to organic phosphate insecticides than *P. californica.*	Jensen and Gaufin (1964)
Endrin	*Gammarus lacustris*	BSA	–	0.0115 (T4A)	a e	Emulsible concentrates were prepared from technical grade insecticides with acetone as the solvent. Symptoms prior to death were observed and recorded on graphs.	Nebeker and Gaufin (1964)
Endrin	Bluegill	BSA	–	0.0006 (T4A)	a	Assays were conducted in soft water at 25 C. Decrease in brain cholinesterase was measured in fish exposed to the toxicant.	Weiss (1964)
Endrin	Bluegill	BSA	–	0.7 (T4A) 0.7 (T4A) 0.4 (T4A) 0.4 (T4A) 0.2 (T4A)	a	These experiments were performed to demonstrate that at increased temperatures the toxic effect of most chemicals is increased. For the toxicant concentrations listed, the temperatures were respectively, 45, 55, 65, 75, and 85 F. Data on the effect of time as well as temperature was also reported. The experimental animals all were approximately one grain in weight.	Cope (1965)
Endrin (tech)	Rainbow trout Bluegill	BSA	–	0.00086 (T4A) 0.00025 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
Endrin	Rainbow trout	BSA	–	2.4 (T4A) 1.4 (T4A) 1.1 (T4A) 0.75 (T4A)	a	These experiments were performed to show the effect of temperature on the toxicity. For the toxicant concentrations listed, the temperatures were respectively, 45, 55, and 65 F. The fish all were approximately one grain in weight. Toxicant concentrations for one and 2-day times were also listed.	Cope (1965)
Endrin	*Leiostomus xanthurus* (juvenile)	BCH	–	(O)	–	Endrin at 0.0006 ppm killed half the shrimp exposed in 24 hours. The fish survived a concentration of 0.00005 ppm for 8 months, but a concentration of 0.0001 was usually lethal in 5 days.	Butler (1965)
Endrin	*Fundulus similis* (juvenile)	BSA	–	0.000079 (O)	a	Water temperature was 21 C. The figure reported is a 24-hr EC_{50}.	Butler (1965)

Endrin	*Dorosoma cepedianum*	BSA	–	(O)	a d e	The critical level of Endrin in the blood (0.10 μg/g) of gizzard shad as a result of laboratory exposures was also applicable for shad exposed to Endrin in a natural system.	Brungs and Mount (1967)
Endrin	*Palaemonetes kadiakensis*	BSA	–	(N) 6.5 (T1½A) (TB) 9.5 (T1½A)	a c f	Test organisms were collected from 2 locations, Twin Bayou (TB), Sunflower Co., Miss. (agricultural area) and Noxubee National Wildlife Refuge (N), Noxubee Co., Miss. (non-agricultural area) and evaluated in laboratory bioassays. The Twin Bayou shrimp were more resistant.	Ferguson, et al (1965)
Endrin	*Gambusia affinis*	BSA	–	0.0005-0.002 (T3A)	a c d e	Test fish were collected from 8 different locations of the Mississippi River. The 3-day TL_m values were made to determine if a resistance gradient existed. The data indicated that there was none.	Ferguson, et al (1966)
	Ictalurus melas			0.0004-0.002 (T3A)			
Endrin	*Lepomis cyanellus* *Gambusia affinis* *Ictalurus melas*	BSA	–	0.001-0.048 (O)	–	Muds reduced the toxicity of chlorinated hydrocarbon insecticides to fish. Lethal quantities of pesticides enter national waters and muds may contain sorbed pesticides in excess of lethal quantities. Although the chemicals can be leached with organic solvents, they were either not released in lethal amounts or slowly released in standing water.	Ferguson, et al (1965)
Endrin	*Acroneuria pacifica*	BSA	–	0.0003 (T4A)	a c	Additional TL_m data are given.	Gaufin, et al (1965)
	Ephemerella grandis			0.005 (T4A)			
	Gammarus lacustris			0.0115 (T4A)			
	Pteronarcys californica			0.0024 (T4A)			
Endrin	*Pteronarcys californica*	BSA	–	0.002 (T4A)	a	Unspecified chemical characteristics of assay water were determined by standard methods. General comments were made concerning "standardized" conditions, use of "soft" water, and use of emulsifying agents. Additional data are presented.	Gaufin, et al (1965)
	Acroneuria pacifica			0.0004 (T4A)			
	Ephemerella grandis			0.005 (T4A)			
	Daphnia magna			0.4 (T 50 hr A)			
	Gammarus lacustris			0.01 (T4A)			
Endrin	*Gambusia affinis*	BSA	–	(O)	a	The effect of combinations of pesticides was studied. In general, the results reflected the extreme levels of Endrin and Toxaphene resistance in the resistant population. The results failed to indicate additive effects wherein the combination mortality exceeded the sum of the mortalities produced by the individual insecticides.	Ferguson and Bingham (1966)
Endrin	*Leiostomus xanthurus*	BCFA	–	0.00045 (T1A)	a i	The duration of exposure was important when determining the sublethal concentrations of Endrin to fish. Data are given as LC_{50}.	Lowe (1966)
	Mugil cephalus			0.0026 (T1A)			
	Brevoortia patronus			0.00080 (T1A)			
	Fundulus similis			0.00023 (T1A)			
	Cyprinodon variegatus			0.00032 (T1A)			

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Endrin	*Fathead minnow*	BCFA	–	0.47 ppb (T4A) 0.50 ppb (T4A)* 0.66 ppb (T4A)** * clay **charcoal	a c d e	The effect of suspended particles on Endrin toxicity was studied. Presence of clay particles had no effect, while activated charcoal reduced toxicity.	Brungs and Bailey (1966)
Endrin	Oyster	BCF	–	0.01-1.0 (SB4)	a	Seawater was employed in this experiment.	Butler (1966)
Endrin	*Salmo gairdneri*	BSA	–	0.0005 (T2A)	a	This paper reports acute toxicity of a number of compounds, and discusses sub-acute mortality as well. Effects of reproduction and behavior are also discussed. Data presented as EC_{50}.	Cope (1966)
	Lepomis macrochirus			0.0003 (T2A)			
	Ictalurus punctatus			0.001 (T2A)			
	Pteronarcys californicus			0.001 (T2A)			
	Baetis sp			0.005 (T2A)			
	Daphnia pulex			0.020 (T2A)			
	Simocephalus serrulatus			0.026 (T2A)			
Endrin	*Ictalurus natilis* *I. melas* *Gambusia affinis* *Lepomis cyanellus* *Notemigonus chrysoleneas*	FR	Miss.	(O)	a	This paper deals with Endrin resistance in fish The TL_m 36 hours values for yellow bullheads from a contaminated area was 75 ppb, while the value for fish from an unsprayed area was only 1.25 ppb. Mosquito fish from a contaminated area tolerated 1500 ppb of Endrin, while golden shiners and green sunfish tolerated 1000 to 250 ppb, respectively. Bullheads were apparently more susceptable to the poison, but there seemed to be evidence that fish can develop a tolerance to the toxicant.	Ferguson and Bingham (1966)
Endrin	*Acroneuria pacifica* *Pteronarcys californica*	BSA & CFCH	–	0.00032 (T4A) 0.000035 (T30CH) 0.0024 (T4A) 0.0012 (T30CH)	a c d e	Additional data are presented.	Jensen and Gaufin (1966)
Endrin	*Buteo buteo* *Accipiter gentilis* *Accipiter nisus* *Falco tinnunculus* *Tyto alba* *Strix aluco*	FO	Netherlands	(O)	–	The results of this study show that birds of prey and fish-eating birds found dead in the Netherlands accumulated large amounts of different chlorinated hydrocarbon insecticides. In most cases the liver had the highest concentration of toxicant, ranging from 0.3 ppm. Most chlorinated hydrocarbons tended to accumulate in the fat depots of the body. In instances where mesenterial fat was analyzed the concentration of toxicant was found to be as high as 15.7 ppm.	Koeman and van Genderen (1966)

	Osio otus *Falco pereginus* *Platalea leucorodia* *Haematopus ostralegus* *Steran sandvicensis* *Sterna hirundo* *Larus ridibundus* *Somateria mollissima* *Tadorna tadorna*		Netherlands	(O)	–	The results of this study show that birds of prey and fish-eating birds found dead in the Netherlands accumulated large amounts of different chlorinated hydrocarbon insecticides. In most cases the liver had the highest concentration of toxicant, ranging from a trace to 3.0 ppm. Birds feeding predominantly on crustacea, molluscs, and fish contained significant amounts.	Koeman and van Genderen (1966)
Endrin	*Ictalurus punctatus*	BCFCHA	–	(O)	a	Catfish blood content acutely toxic in 10 days or less—0.25-0.3 ppb, nonlethal (exposure during 44 days)—0.1-0.2 ppb. Endrin was not stored in blood and 0.3 ppb appeared to be the critical concentration level in the blood.	Mount, et al (1966)
Endrin	*Daphnia carinata*	BSA	–	0.050 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited for 78 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
	Simocephalus serrulatus *Daphnia pulex*	BSA	–	0.026 (SB) 0.020 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 48 hr. Data cited are for 60 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
	Daphnia magna	BSA	–	0.900 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
	Simocephalus serrulatus *Daphnia pulex*	BSA	–	4.90 (SB) 3.20 (SB)		Comment same as above.	Sanders and Cope (1966)
Endrin	Catfish Buffalo fish Perch Bluegill Carp	L	–	(O)	–	Chemical analysis showed residues of <0.01 to 0.04 ppm in catfish, <0.01 in buffalo fish, and 0.05 ppm in carp. Perch were reported to contain 0.02 and bluegills 0.01 ppm, but this may be doubtful inasmuch as the method of anaylsis uses was thought to have an interference from toxaphene which had been used previously. The treated area had been sprayed with Endrin at 0.3 lb/acre.	Sparr, et al (1966)

Chemical	Organism	Bioassay or Field Study$^{(1)}$	Field Location$^{(2)}$	Toxicity, Active Ingredient, ppm$^{(3)}$	Experimental Variables Controlled or Noted$^{(4)}$	Comments	Reference (Year)
Endrin	*Mya arenaria* *Crassostrea virginica* *Corbicula manillensis* *Mercenaria mercenaria* *Rangia cuneata*	BCFCH	–	(O)	–	Results are recorded as a range of uptake of the chemical by 5 species of aquatic mollusks. An uptake or concentration of 500-1250X resulted.	Butler (1967)
Endrin	*Fundulus similis* *Leiostomus xanthurus*	BCFCH	–	0.0001 (SB 6 mo) 0.1 (SB 3 mo)	–	When these fish were examined for residues at the end of 6 months, 92.0 ppb Endrin residue was found.	Butler and Johnson (1967)
Endrin	Oyster	FE	Galveston Bay, Texas	(O)	–	Oysters from the area were found to contain <0.01 to 0.02 ppm.	Casper (1967)
Endrin	*Puntius puckelli*	BSA	–	0.00125 (T4A)	a c d e l m	Tap water was used as diluent. Toxicity data are given as TL_m's in ppm for 24, 48, 96 hr. The pH of the water averaged 8.3. The study was conducted in India.	Rao, et al (1967)
Endrin	*Ictalurus melas*	BSA	–	50 ppb (T1/2A)	a	The principal mode of Endrin entry in the body of the fish is by way of the gill surfaces. The toxicity figure cited is for 10 hr.	Velsen and Alderdice (1967)
Endrin	Vascular plants Algae Chub Largemouth bass Clam	FL	Tule Lake, Ore.	(O)	–	Endrin was applied at the rate of 1.6 lb/acre/year. Plants contained 1.6 to 12.5 ppb. Algae contained 2.0 to 22.3 ppb. Chubs contained 4.0 to 198.0 ppb. Bass contained 2.0 to 107.0 ppb. Clams contained 1.7 to 90.0 ppb. Concentrations of 0.007 to 0.01 ppb occurred in the water.	Godsil and Johnson (1968)
Endrin	*Notemigonus crysoleucas*	BSA	–	(O)	–	This paper deals with the resistance and susceptibility of populations of golden shiners to Endrin. Two populations of golden shiners from agricultural areas possessed different levels of resistance to Endrin. At 1.0 ppm, Endrin killed 50 susceptible golden shiners in 75 min, but only 40 of 50 resistant shiners in 40 hours. Endrin residues in whole bodies of resistant shiners killed by Endrin were as much as 82 times those of the susceptible shiners. It was concluded that the use of a critical concentration in the blood for diagnosis of Endrin-caused mortality must be based on the tolerance of local populations.	Ludke, et al (1968)
Endrin	*Limnephilus rhombicus* *Sialis* sp *Gammarus* sp		Knights Creek, Wisc.	(O)	–	Pesticide usage in an orchard did not significantly contaminate the aquatic environment of this creek adjacent to the treatment as determined by residue analysis.	Mowbry, et al (1968)

Endrin	*Esox americanus*	BSA	–	(K) 7.1 hr (O)	Not given	Mosquitofish (*Gambusia affinis*) were exposed to 2 ppm Endrin solutions for 7 days. The fish were somewhat resistant to Endrin. These fish were then force-fed to the 8 species of vertebrates listed. Survival time is listed. Mortality was 100 percent in this time period except for *P. scripta elegans* and *A. piscivorus*. For the *P. scripta elegans* mortality was 72 percent in 112.8 hr and for the *A. piscivorus* the mortality was 91% in 27.1 hr.	Rosato and Ferguson (1968)
	Micropterus salmoides			(K) 12.6 hr			
	Lepomis macrochirus			(K) 9.4 hr			
	Rana catesbeiana			(K) 15.6 hr			
	Pseudemys scripta elegans						
	Natrix erythrogaster flavigaster			(K) 65.4 hr			
	Natrix rhombifera			(K) 54.0 hr			
	Ancistrodon piscivorus			(O)			
Endrin	*Pteronarcys californica* (naiads)	BSA	–	0.00025 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
	Pteronarcella badia (naiads)			0.00054 (T4A)			
	Claassenia sabulosa (naiads)			0.00076 (T4A)			
EPN miticide (ethyl-p-nitro-phenyl thio-benzenephos-phonate, 31.5 percent)	Lymnaeid snails	BSA	–	(O)	–	Each test container (500-ml beaker) was filled with ditch water. Less than 100% mortality occurred in concentrations of 1:100,000.	Batte, et al (1951)
EPN-300 (25%)	*Pimephales promelas*	BSA	–	0.80 (T4A)	a c d e f	Tests were performed in both hard and soft water. Additional tolerance limit values are given.	Henderson and Pickering (1958)
EPN	Fathead minnow	BSA	–	0.25 (T4A)	a	It was the authors opinion that pH, alkalinity and hardness, within the usual range in natural waters, had little effect on the toxic effect of the compounds studied. The values given are from Henderson, Pickering, and Tarzwell, "The Relative Toxicity of Ten Chlorinated Hydrocarbon Insecticides to Four Species of Fish". It is interesting that the different tables from the above book (as reported in this paper) report widely different values for the same compounds. This experiment was performed in hard water.	Tarzwell (1959)
EPN	*Daphnia magna*	BSA	–	0.0001 (O)	a	The indicated concentration immobilized *Daphnia* in 50 hours.	Anderson (1960)
EPN	*Pimephales promelas*	BSA	–	0.2 (T4A)	a d e f	Concentrations were based on percent active ingredient.	Henderson, et al (1959)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
EPN	*Pimephales promelas*	BSA	–	0.20 (T4A)	a	Bioassay investigations of the new insecticides indicate that in general the organic phosphorus compounds are not as toxic to fish as are the chlorinated hydrocarbons. The toxicity of most of these materials was not significantly influenced by water quality. Therefore it is to be expected that the toxicity of these materials will not differ significantly in different streams.	Tarzwell (1959)
EPN	*Lepomis macrochirus*	BSA	–	0.1 (O)	a c d f	This paper reports the effect of insecticides in reducing the anticholinesterase in a fish brain within 2-8 hours. The inhibition of the enzyme was a function of the concentration of the insecticide, extent of exposure, and specific chemical nature of the compound.	Weiss (1959)
	Micropterus salmoides			0.1 (O)			
	Notemigonus crysoleucas			0.1 (O)			
	Carassius auratus			0.1 (O)			
EPN	*Micropterus salmoides*	BSA	–	0.5 (O)	–	The degree of reaction to the cholinesterase-inhibiting insecticides is not only a function of time and concentration, but also of chemical and biological species. This paper reports many analyses of brain cholinesterase activity which is expressed as percentage of normal. The data are reported as LT_{50} which was the time required for 0.5 ppm of the chemical to kill 50 percent of the fish. For bass the LT_{50} was 9 hr 30 min and for fatheads 72 hr.	Weiss (1961)
	Pimephales promelas			0.5 (O)			
EPN-300, wettable powder (25 percent)	*Pimephales promelas*	BSA	–	1.1 (T4A)	a c d e	Soft water primarily was the test medium. TL_m's reported for 24, 48, and 96 hr. Acetone or alcohol used as solvent or carrier in most cases.	Pickering, et al (1962)
	Lepomis macrochirus			0.44 (T4A)			
	Carassius auratus			2.3 (T4A)			
EPN (tech, 100 percent)	*Pimephales promelas*	BSA	–	0.25 (T4A)	a c d e	Comment same as above.	Pickering, et al (1962)
	Lepomis macrochirus			0.10 (T4A)			
	Carassius auratus			0.45 (T4A)			
	Lebistes reticulatus			0.032 (T4A)			
EPN	*Chaoborus astictopus*	BSA	–	0.0036 (T1A)	a	Toxicity value given is for the fourth instar larvae.	Hazeltine (1963)
EPN	Bluegill	BSA	–	0.1 (T4A)	a	Assays were conducted in soft water at 25 C. Decrease in brain cholinesterase was measured in fish exposed to the toxicant.	Weiss (1964)

EPN	*Carassius auratus* *Lepomis macrochirus* *Notemigonus crysoleucas*	BSCH	—	10.0 (O)* 1.0 (O)** 0.05 (O)*** 1.0 (O)* 0.05 (O)*** 10.0 (O)* 1.0 (O)** * response, 15 days ** no response, 15 days ***no response, 30 days	a c d e	Toxicity was determined by measuring acetylcholinesterase activity in the brains of fish. Concentrations are given in ppb as either response or not response in 15 or 30 days.	Weiss and Gakstatter (1964)
Eptam	*Crassostrea virginica* *Penaeus setiferus* *Mugil cephalus* Phytoplankton	BCFA & BSA		5.0 (0.43%) 0.63 (O) 20.0 (10% T2A)	—	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster — 96-hr EC_{50} — Conc. which decreased shell growth. Shrimp — 48-hr EC_{50} — Conc. which killed or paralyzed 50% of test animals. Fish — 48-hr EC_{50} — Conc. which killed 50%. Phytoplankton — Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
Erythromycin thiocyanate	*Salmo gairdnerii*	BSA	—	(O)	a c e i p	A dosage of 500 milligrams of erythromycin thiocyanate per kilogram per day (five times the usual therapeutic level) was required to produce overt symptoms of toxicity in rainbow trout.	Warren (1963)
Erythromycin thiocyanate	*Salmo gairdnerii* *Salmo trutta* *Salvelinus fontinalis* *Salvelinus namaycush* *Ictalurus punctatus* *Lepomis macrochirus*	BSA	—	100 (NTE)	a f	Variance and the 95-percent confidence interval (C.I.) were also determined.	Willford (1966)
Essolvene	*Pandalus montagni* *Crangon crangon* *Carcinus maenas* *Cardium edule*	BSA	—	8.6 (T2A) 9.6 (T2A) 17.5 (T2A) 63.0 (T2A)	a e	Experiments were conducted in tanks holding 10 liters of seawater at 15 C. It was shown that the toxicity of this solvent emulsifier decreased with time due to evaporation of the solvent. Essolvene at a concentration of 10 ppm killed 100% of *Crangon crangon* larvae in 3 hr; at 33.3 ppm it killed 100% of *Carcinus maenas* in 3 hr.	Portmann and Connor (1968)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Estron (2,4-5T)	*Pontederia cordata*	FL	Fla.	(O)	–	At 6.4 lb/acre, 80 percent control of pickerel weed was obtained.	Copeland and Woods (1959)
Esteron 99	*Lepomis macrochirus*	BSA	–	1,200 (T 18 hr)	a	The experiment was conducted at 65 F. Fish were 2 in. long.	Cope (1963)
Esteron 99	*Lepomis* sunfish	FL	Okla.	(O)	–	Three ponds were partitioned with polyvinyl chloride sheeting to provide 6 test spaces for fish. Mortality of the fish was 19% in the 10-ppm pond in the first week.	Cope (1963)
Esteron 99 (EC)	*Lepomis macrochirus*	BSA	–	700 (T1A)	a	The experiment was conducted at 75 F. Fish weighed 0.6 g.	Cope (1963)
Esteron 99 (2, 4-D)	*Crassostrea virginica* *Penaeus aztecus* *Leiostomus xanthurus* Phytoplankton	BCFA & BSA	–	0.055 (O) 0.55 (O) 1.5 (T2SA)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
Esteron 99	*Pteronarcys* sp (nymphs)	BSA	–	1.6 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Ethion	*Cyprinodon variegatus* (juvenile)	BSA	–	0.064 (O)	a	Water temperature was 12 C. The figure reported is a 48-hr EC_{50}.	Butler (1965)
Ethion (tech)	*Pimephales promelas* *Lepomis macrochirus* *Lebistes reticulatus*	BSA	–	2.4 (T4A) 0.13 (T4A) 0.13 (T4A)	a c d e f	The toxicity of this substance was not influenced by the quality of the water (pH, hardness, alkalinity).	Pickering and Henderson (1966)
Ethion	*Pteronarcys californica* (naiads)	BSA	–	0.0028 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Ethyl carbo-phenothion	*Chaoborus astictopus*	BSA	–	0.044 (T1A)	a	Toxicity value given is for the fourth instar larvae.	Hazeltine (1963)
Ethyl guthion (EC2)	*Gambusia affinis* *Rana catesbeiana*	FL	Ponds in Ill.	(O)	–	When applied at 0.01 and 0.025 pound per acre active ingredient, 88 and 100 percent fish mortality occurred respectively in 1 day. No bullfrog mortality occurred at 0.8 pound per acre in 1 day.	Mulla, et al (1963)

Ethyl parathion	*Chaoborus astictopus*	BSA	–	(O)	a	Tests were run on bluegill sunfish, *C. astictopus* first instar larvae, and fourth instar larvae, results for larvae were as follows: Fourth instar 0.017 (T1A) First instar 0.0018 (T1A)	Ha[illegible]ltine (1963)
	Lepomis macrochirus			0.021 (T9A)			
Ethyl parathion	*Pteronarcys* sp (nymphs)	BSA	–	0.0051 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Ethyl parathion	*Simocephalus serrulatus*	BSA	–	0.00037 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
	Daphnia pulex			0.00060 (SB)	–		
	Daphnia carinata			0.0005 (SB)			
	Daphnia magna			0.0008 (SB)			
Ethyl guthion	*Pteronarcys* sp (nymphs)	BSA	–	0.002 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Ethyl guthion, (tech)	Rainbow trout	BSA	–	0.019 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
Ethyl guthion	*Salmo gairdneri*	BSA	–	0.023 (T2A)	a	This paper reports acute toxicity of a number of compounds, and discusses sub-acute mortality as well. Effects on reproduction and behavior are also discussed. Data presented as EC_{50}.	Cope (1966)
	Lepomis macrochirus			0.002 (T2A)			
	Pteronarcys californica			0.008 (T2A)			
	Daphnia pulex			0.003 (T2A)			
	Simocephalus serrulatus			0.004 (T2A)			
Ethyl guthion	*Simocephalus serrulatus*	BSA	–	0.0042 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 48 hr. Data cited are for 60 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
	Daphnia pulex			0.0032 (SB)			
Ethyl guthion EC4	*Micropterus salmoides*	BSA	–	0.05 (O) 0.10 (O) 0.50 (K1)	a e	At 0.05 ppm, 25 percent mortality occurred in 1 day. At 0.10 ppm, 90 percent mortality occurred in 1 day. For bass: Experiments were carried out in fiber glass tubs filled with well water. Fish weights ranged from 2 to 6 pounds. For carp: Experiments were carried out in plastic tubs lined with saran plastic. Fish weights averaged 217 grams.	Mulla, et al (1967)
	Cyprinus carpio			0.01 (K1) 0.05 (K 5 hr) 0.10 (K 5 hr)			

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Exalgae	*Chlorella pyrenoidsa*	L	–	5 (AC 1/2 hr)	–	Describes a bioassay method to differentiate between an algicide (AC) and an algistat (AS). The treated culture was subcultured as time progressed. Allen's medium was used.	Fitzgerald and Faust (1963)
F-98	*Onchorynchus tshawytscha*	BSA	–	0.08 (T1A)	a c d e	Concentrations were based on percent active ingredient.	Bond, et al (1960)
Fairfield 279	*Salmo gairdneri*	BSA	–	360 (T1A)	a	The experiment was conducted at 55 F. Fish weighed 0.5 g.	Cope (1963)
Fairfield OT 60-6	*Salmo gairdneri*	BSA	–	100 (T1A)	a	The experiments were conducted at 55 F. Fish weighed 0.8 g.	Cope (1963)
Fenac (sodium salt)	Redear sunfish	BSA	–	(O)	a	The experiment was conducted at 75 F. Fish weighed 3 g. No mortality was noted with concentrations of 12,000 mg/1 at 48 hr.	Cope (1963)
	Salmo gairdneri			10,000 (T1A) 7,500 (T2A)		The experiments were conducted at 65 F. Fish weighed 0.6 g.	
Fenac	*Lepomis macrochirus*	BSA	–	22.5 (T2A) L 15.0 (T2A) G	a c d e g	Toxicity data for 24 and 48 hours are presented for liquid (L) and granular (G) formulations. Various commercial formulations were tested. The liquid formulations were almost invariably more toxic than the granular ones.	Hughes and Davis (1965)
Fenac (sodium salt)	*Pteronarcys* sp (nymphs)	BSA	–	47 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Fenac acid (tech)	Bluegill	BSA	–	41 (T4A)	a	This is an estimated LC_{50} value at temperatures from 55 to 75 F.	Cope (1965)
Fenac (sodium salt, WP)	Bluegill	BSA	–	14 (T4A)	a	Comment same as above.	Cope (1965)
Fenac (acid)	*Pteronarcys* sp (nymphs)	BSA	–	56 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Fenac, Na	*Salmo gairdneri*	BSA	–	7.500 (T2A)	a	This paper reports acute toxicity of a number of compounds, and discusses subacute mortality as well. Effects on reproduction and behavior are also discussed. Data presented as EC_{50}.	Cope (1966)
	Lepomis macrochirus			19.000 (T2A)			
	Pteronarcys californica			80.000 (T2A)			
	Daphnia pulex			4.500 (T2A)			
	Simocephalus serrulatus			6,600 (T2A)			
Fenac (Na salt)	*Daphnia magna*	BSA	–	100 (O)	a c d i q	Toxicity, in terms of median immobilization concentration (IC_{50}), is presented for *Daphnia*; median lethal concentration (LC_{50}) for rainbow trout and bluegill are reported.	Crosby and Tucker (1966)
	Rainbow trout			7.5 (O)			
	Bluegill			19 (O)			

Fenac (sodium salt)	*Simocephalus serrulatus*	BSA	–	6.6 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
	Daphnia pulex		–	4.5 (SB)			
Fenac (sodium salt, WP)	Rainbow trout	BSA	–	7.5 (T2A)	–	Data are given as LC_{50}.	Bohmont (1967)
	Bluegill			19.0 (T2A)			
Fenac	*Lepomis macrochirus* (eggs)	L	–	20/5 (O)	–	Fertilized fish eggs of indicated species were placed in 1 liter of test solution and allowed to hatch. Toxicity data are presented as concentration in ppm/number of days survival. Maximum length of test was 8 days. No food was added. Small bluegill were tested to find the highest concentration of chemical which did not cause death in 12 days (S).	Hiltibran (1967)
	Erimyzon sucetta (eggs)			20 (NTE)			
	L. macrochirus (fry)			50 (S)			
Fenac	*Pteronarcys californica* (naiads)	BSA	–	0.06 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Fenac (Na salt)	*Pteronarcys californica* (naiads)	BSA	–	0.055 (T4A)	a c d e f	Comment same as above.	Sanders and Cope (1968)
Fenthion	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	–	0.4 (O)	a	Stones heavily populated with wild larvae were placed in troughs of running water containing the toxicant. When the larvae became detached from the rocks and floated away, they were assumed to have undergone lethal intoxication. The larvae were exposed to the toxicant for 5 minutes, then in clean water for 24 hours. At that time the number detached amounted to 89 percent.	Jamnback and Frempong-Boadu (1966)
Fenthion (Baytex)	*Micropterus salmoides*	BSA	–	1.75 (L1A)	a	Abate was toxic to fish at a dosage rate necessary to control the larvae of the chironomid midge.	Von Windeguth and Patterson (1966)
	Lepomis macrochirus			1.75 (L1A)			
	Gambusia affinis			2.0 (L1A)			
	Lebistes reticulatus			1.75 (L1A)			
	Palomonetes paludosus			0.011 (L1A)			
	Hyalella azteca			0.016 (L1A)			
	Plankton (Euglena, Coleops)			1.0 (K2)			
	Rotifers			1.0 (K2)			
Fenthion	*Micropterus salmoides*	BSA	–	5.0 (K 3 hr)	a e	Experiments were carried out in plastic tubs lined with saran plastic. Fish weights averaged 217 grams.	Mulla, et al (1967)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Fenthion	*Pteronarcys californica* (naiads)	BSA	–	0.0045 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Fenuron	*Protococcus* sp *Chlorella* sp *Dunaliella euchlora* *Phaeodactylum tricornutum* *Monochrysis lutheri*	BSA	–	29.0 (K) 2.9 (NG) 2.9 (NG) 2.9 (NG) 2.9 (K)	a	This paper concerns the growth of pure cultures of marine plankton in the presence of toxicants. Results were expressed as the ratio of optical density of growth in the presence of toxicants to optical density in the basal medium with no added toxicants. NG = no growth, but the organisms were viable.	Ukeles (1962)
Fenuron	*Leiostomus xanthurus* (juvenile)	BSA	–	(O)	a	Water temperature was 25 C. Fish showed irritation at 1.0 ppm.	Butler (1967)
Fenuron	*Penaeus aztecus*	L	–	(O)	a	Toxicant chemicals were evaluated in sea water at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality. A concentration of 1.0 ppm caused 10 percent mortality.	Butler (1965)
Fenuron	*Crassostrea virginica* *Penaeus aztecus* *Leiostomus xanthurus* Phytoplankton	BCFA & BSA	–	2.0 (NTE) 2.0 (0, 10%) 1.0 (NTE) 41% (O)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
Fenuron (25 percent pellet)	*Lepomis macrochirus*	BSA	–	53.0 (T4A)	–	Laboratory bioassays indicated that toxicity of the different formulations evaluated in this varied greatly with the fish used. Mortality data are expressed as EC_{10}, EC_{50}, etc.	Walker (1965)
Fenuron-TCA (tech)	*Lepomis macrochirus*	BSA	–	5.3 (T4A)	–	Comment same as above.	Walker (1965)
Fenuron-TCA (3 lb/gal)	*Lepomis macrochirus* *Micropterus salmoides*	BSA	–	4.8-6.5 (T4A) 7.4 (T4A)	–	Comment same as above.	Walker (1965)

Fenuron TCA	*Lepomis macrochirus* *L. cyanellus* *Micropterus dolomieui* *Erimyzon sucetta* *L. macrochirus* (fry)	L	–	10 (NTE) 10 (NTE) 10 (NTE) 10 (NTE) 20 (S)	–	Fertilized fish eggs of indicated species were placed in 1 liter of test solution and allowed to hatch. Toxicity data are presented as concentration in ppm/number of days survival. Maximum length of test was 8 days. No food was added. Small bluegill were tested to find the highest concentration of chemical which did not cause death in 12 days (S).	Hiltibran (1967)
Fermate	Channel catfish (fingerlings)	BSA	–	12.6 (K 27 hr A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Fermate	*Salvelinus fontinalis* x *Salmo trutta* *Catostomus commersoni* *Micropterus salmoides*	FPCH	N.Y.	0.5 (S23) 0.5 (S23) 0.5 (S23)	a c d	Conventional farm ponds were used having an average surface area of 0.3 acre and a maximum depth of 7-9 ft. Toxicity (in ppm) to fish as maximum safe concentration (S) for 23 days was determined. Concentration of 0.5 ppm was required to control algae.	Eipper (1959)
Fermate	*Pimephales promelas* *Lepomis*	BSA	–	3.1 (T4A)	a c d e f	The toxicity of this substance was influenced by the quality of the water (pH, hardness, alkalinity). The TL_m was lower in hard water.	Pickering and Henderson (1966)
Folidol	*Tilapia massambica* *Gambusia affinis*	BSA	–	0.6 (T2A) 0.1 (T2A)	a c d e f p	The test animals were conditioned for 48 hours prior to use.	Sreenivasan and Swaminathan (1967)
Folpet [N-(trichloromethylthio)-phythalimide]	*Brachydanio rerio*	BSA	–	1 (O)	a	At 1 ppm all larvae were killed within 48 min. The TL_{50} was 34 min and LD_{50} was 0.71 ppm.	Abedi and Turton (1968)
Folithion or Sumithion (=fenitrothion)	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	–	0.4 (O)	a	Stones heavily populated with wild larvae were placed in troughs of running water containing the toxicant. When the larvae became detached from the rocks and floated away, they were assumed to have undergone lethal intoxication. The larvae were exposed to the toxicant for 5 minutes, then in clean water for 24 hours. At that time the number detached amounted to 65 percent.	Jamnback and Frempong-Boadu (1966)
Furron	Water lettuce	FL	Lakes in Fla.	(O)	–	Application rates of 4 to 5 lb/acre controlled water lettuce.	Phillippy (1961)
Furazolidone	*Salmo trutta* *Salmo gairdnerii* *Salvelinus fontinalis*	BCH	–	(O)	a c	The chemical was nontoxic to brown, rainbow, and brook trout at levels up to 500 mg per kg of body weight per day when force-fed for 14 consecutive days. Therapeutic levels for control of furnuculosis appear to be as low as or lower than 10 milligrams of chemical per kilogram of body weight per day for 14 days. To have complete control of the disease, a dosage of at least 75 milligrams of furazolidone per kilogram of body weight was given.	Post and Keiss (1962)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Furoxone	*Salvelinus fontinalis*	BSA	–	(O)	a e	*Aeromonas salmonicide* is the bacterium causing furunculosis in fish. The toxicity level of this chemical indicates that this drug could be used as a therapeutic measure for *A. salmonicide.* 500 milligrams per kilogram per day used for 15 successive days showed no pathological effect on brook trout.	Post (1959)
G-27365 (EC2)	*Gambusia affinis*	FL	Ponds in Ill.	(O)	–	When applied at 0.2 and 0.4 pound per acre active ingredient, 8 and 100 percent fish mortality occurred respectively in 1 day.	Mulla, et al (1963)
	Rana catesbeiana					No bullfrog mortality occurred at 0.8 pound per acre in 1 day.	Mulla, et al (1963)
G-28029 (EC2)	*Gambusia affinis*	FL	Ponds in Ill.	(O)	–	When applied at 1.6 pounds per acre active ingredient, 6 percent fish mortality occurred in 1 day.	Mulla, et al (1963)
	Rana castesbeiana					No bullfrog mortality occurred at 1.6 pounds per acre in 1 day.	
G-30493 (EC2)	*Gambusia affinis*	FL	Ponds in Ill.	(O)	–	When applied at 0.8 pound per acre active ingredient, 2 percent fish mortality occurred in 2 days.	Mulla, et al (1963)
	Bufo boreas			(O)		No toad mortality occurred at 0.8 pound per acre in 1 day.	
	Scophiopus hammondi			(O)			
G-30494 (EC2)	*Gambusia affinis*	FL	Ponds in Ill.	(O)	–	When applied at 0.8 pound per acre active ingredient, 100 percent fish mortality occurred in 1 day.	Mulla, et al (1963)
	Bufo boreas			(O)		When applied at 0.4 pound per acre, 5 percent toad mortality occurred in 1 day.	
	Scophiopus hammondi			(O)			
GC-405 (zinc nicotinyl fluosilicate)	*Australorbis glabratus*	BSA and FL	Puerto Rico	Failed	c	Seven of the tested compounds failed to meet acceptability criteria – that is, complete kill after 6-hr exposure to 10 ppm. They were not used in field tests. Field tests showed WL 8008 to be highly effective.	Seiffer and Schoof (1968)
GC-2131 [1-chloro-2,4-phenylene-bis-(0,0-diethyl phosphorothiolate]	*Australorbis glabratus*	BSA and FL	Puerto Rico	Failed	c	Comment same as above.	Seiffer and Schoof (1968)
GC-3582 (EC4)	*Gambusia affinis*	FL	Ponds in Ill.	(O)	–	When applied at 0.025 and 0.05 pound per acre active ingredient, 4 and 80 percent fish mortality occurred in 1 day.	Mulla, et al (1963)
	Rana catesbeiana					When applied at 1.6 pounds per acre, 100 percent bullfrog mortality occurred in 1 day.	

GC-3582 (EC4)	*Micropterus salmoides* *Cyprinus carpio*	BSA	–	0.05 (O) 0.10 (K1) 0.005 (K1) 0.01 (K 5 hr) 0.05 (K 3 hr)	a e	At 0.05 ppm, 60 percent mortality occurred in 1 day. For bass: Experiments were carried out in fiber glass tubs filled with well water. Fish weights ranged from 2 to 6 pounds. For carp: Experiments were carried out in plastic tubs lined with saran plastic. Fish weights averaged 217 grams.	Mulla, et al (1967)
GC-3583 (EC4)	*Micropterus salmoides*	BSA	–	0.10 (O) 0.50 (K1)	a e	No mortality occurred at 0.10 ppm in 4 days. Experiments were carried out in fiber glass tubs filled with well water. Fish weights ranged from 2 to 6 pounds.	Mulla, et al (1967)
GC-3707 (tech)	*Lepomis macrochirus*	BSA	–	600 (T1A)	a	The experiment was conducted at 75 F.	Cope (1963)
GC-3707 (EC)	*Salmo gairdneri*	BSA	–	170 (T1A)	a	The experiment was conducted at 65 F.	Cope (1963)
GC-3707 (WP)	*Salmo gairdneri*	BSA	–	95 (T1A)	a	The experiment was conducted at 65 F.	Cope (1963)
GC-4072 (50 percent EC)	*Gambusia affinis*	FL	Ponds Bakersfield, Cal.	0.2 (K1) 0.8 (K1)	a c	Toxicity values indicate application rates in lb/acre. The experiments were conducted in cages placed in the ponds.	Mulla and Isaak (1961)
GC-4072 (tech)	*Lepomis macrochirus*	BSA	–	3 (T1A)	a	The experiments were conducted at 75 F.	Cope (1963)
GC-4072 (EC4)	*Micropterus salmoides*	BSA	–	0.50 (O) 1.00 (O)	a e	At 0.50 ppm, 6 percent mortality occurred in 1 day. At 1.00 ppm, 66 percent mortality occurred in 1 day. At 1.50 ppm, 100 percent mortality occurred in 2 days. Experiments were carried out in fiber glass tubs filled with well water. Fish weights ranged from 2 to 6 pounds.	Mulla, et al (1967)
GC-9160 (EC2)	*Gambusia affinis* Tadpole shrimp	FL	Cal.	(O) (O)	–	At an application rate of 2.0 lb/acre, 62% mortality of the fish occurred in 24 hours. Tadpole shrimp survived this treatment.	Mulla (1966)
GS-12968 (EC4)	*Gambusia affinis*	FL	Cal.	(O)	–	At a concentration of 0.4 lb/acre, 72% mortality of the fish occurred in 24 hours.	Mulla (1966)
GS-13005 (EC4)	*Gambusia affinis* *Rana catesbeiana*	FL	Cal.	0.4 (K1) (O)	–	Toxicity value in lb/acre. No mortality in tadpoles of *R. catesbeiana* occurred during an exposure period of one week.	Mulla (1966)
GS-13005	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	–	0.4 (O)	a	Stones heavily populated with wild larvae were placed in troughs of running water containing the toxicant. When the larvae became detached from the rocks and floated away, they were assumed to have undergone lethal intoxication. The larvae were exposed to the toxicant for 5 minutes, then in clean water for 24 hours.	Jamnback and Frempong-Boadu (1966)
Gamlen CW	*Pandalus montagni* *Cardium edule*	BSA	–	14.6 (O) 69.5 (O)	a e	Experiments were conducted in tanks holding 10 liters of sea water at 15 C. It was shown that the toxicity of this solvent emulsifier decreased with time due to evaporation of the solvent. Gamlen CW at a concentration of 33.3 ppm killed 95% of *Crangon crangon* larvae in 3 hr.	Portmann and Connor (1968)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Gamlen D	*Pandalus montagni*	BSA	–	11.5 (T2A)	a e	Experiments were conducted in tanks holding 10 liters of sea water at 15 C. It was shown that the toxicity of this solvent emulsifier decreased with time due to evaporation of the solvent. Gamlen D at a concentration of 33.3 ppm killed 100% of *Crangon crangon* larvae in 3 hr.	Portmann and Connor (1968)
	Crangon crangon			9.6 (T2A)			
	Cardium edule			38.8 (T2A)			
Gamlen OSR	*Pandalus montagni*	BSA	–	12.5 (T2A)	a e	Comments same as above except that Gamien OSR at a concentration of 10 ppm killed 95% of *Crangon crangon* larvae in 3 hr.	Portmann and Connor (1968)
	Crangon crangon			8.8 (T2A)			
	Carcinus maenas			20.4 (T2A)			
	Cardium edule			15.8 (T2A)			
Gammexane powder (larvicide)	*Tilapia melanopleura*	FLCH	Tanganyika	1 lb (0% K)	–	Trial periods were for 20 weeks. Sublethal effects such as impaired breeding, retarded growth, or altered taste were not detected. Dosages are given as lb/acre of surface water.	Webbe and Shute (1959)
Gamosol solvent "D"	*Daphnia magna*	BSA	–	13.7 (T1A) 2.9 (T2A) 1.5 (T3A)	e	Crude oil plus emulsifier had the following values. 24.4 (T1A) 10.7 (T2A) 9.1 (T3A)	Dowden (1962)
Garlon	*Myriophyllum heterophyllum* *Utricularia* sp	FL	Farm ponds in Ga.	(O)	–	Garlon was developed as an overall herbicide containing 4 lb/gal dalapon and 1/2 lb/gal Silvex acid. It has given indications of control of several species of weeds, such as *Myriophyllum heterophyllum* and *Utricularia* sp. However, present results are inconclusive and this herbicide warrants further investigation and experimentation.	Thomaston, et al (1959)
Guthion (25% WP)	Green sunfish Orange spotted sunfish White crappie Bluegill Largemouth bass Gizzard shad Freshwater drum Gar Carp Longnose gar Golden shiners	FL	Ponds in Ark.	0.25-1.8 (O)	d g	Catfish were more tolerant to Guthion than the other species of fish tested. All other species of fish were quickly affected by applications of 1.0 ppm. Field studies were conducted in ponds ranging from 0.25-1.8 acre-feet in volume. Survival values were determined by draining the ponds whenever possible. Residue studies indicated that the chemical disappeared from the water in less than 2 weeks and that the chemical is no longer detectable in catfish flesh after 6 weeks. Cladocera and rotifers were not eliminated from the treated ponds and, in many field collections, were more numerous than in untreated ponds.	Surber (1943)

	Fathead minnows Bigmouth buffalo Black bullheads Channel catfish Warmouth						
Guthion	*Pimephales promelas* *Lepomis macrochirus*	BSA	–	0.09 (T4A) 0.005 (T4A)	a d e f	Concentrations were based on percent active ingredient.	Henderson, et al (1959)
Guthion	*Gambusia affinis*	BSA	–	0.05 (K 53%)	a	Chemicals were dissolved in acetone, and tests were run in triplicate. Toxicity is given as average percent fish killed in 24 hr.	Lewallen (1959)
Guthion	*Pimephales promelas* *Lepomis macrochirus*	BSA	–	0.093 (T4A) 0.0052 (T4A)	a	Bioassay investigations of the new insecticides indicate that in general the organic phosphorus compounds are not as toxic to fish as are the chlorinated hydrocarbons. The toxicity of most of these materials was not significantly influenced by water quality. Therefore it is to be expected that the toxicity of these materials will not differ significantly in different streams.	Tarzwell (1959)
Guthion	*Lepomis macrochirus* *Micropterus salmoides* *Notemigonus crysoleucas* *Carassius auratus*	BSA	–	0.1 (O) 0.1 (O) 0.1 (O) 0.1 (O)	a c d f	This paper reports the effect of insecticides in reducing the anticholinesterase in a fish brain within 2-8 hours. The inhibition of the enzyme was a function of the concentration of the insecticide, extent of exposure, and specific chemical nature of the compound.	Weiss (1959)
Guthion	*Oncorhynchus kisutch* *Oncorhynchus tshawytscha* *Salmo gairdnerii* *Gasterosteus aculeatus*	BSA	–	4.2 (T4A) 4.3 (T4A) 3.2 (T4A) 12.1 (T4A)	a c d e	Chemical dissolved in acetone. TL_m expressed in ppb.	Katz (1961)
Guthion	*Micropterus salmoides* *Pimephales promelas*	BSA	–	0.5 (O) 0.5 (O)	–	The degree of reaction to the cholinesterase-inhibiting insecticides is not only a function of time and concentration, but also of chemical and biological species. This paper reports many analyses of brain cholinesterase activity which is expressed as percentage of normal. The data are reported as LT_{50} which was the time required for 0.5 ppm of the chemical to kill 50 percent of the fish. For bass the LT_{50} was 40 min and for the fathead 40 min.	Weiss (1961)
Guthion	*Cyprinodon variegatus*	BCFCH	–	0.01 (SB1)	a	Little or no information was given about test procedures and further results.	Das and Needham (1961)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Guthion (tech, 90 percent)	*Carassius auratus* *Lebistes reticulatus*	BSA	–	1.4 (T4A) 0.12 (T4A)	a c d e	Soft water primarily was the test medium. TL_m's reported for 24, 48, and 96 hr. Acetone or alcohol used as solvent or carrier in most cases.	Pickering, et al (1962)
Guthion (EC1.5)	*Gambusia affinis* *Bufo boreas* *Scaphiopus hammondi*	FL	Ponds in Ill.	(O) (O) (O)	–	When applied at 0.1 pound per acre active ingredient, 100 percent fish mortality occurred in 1 day. No toad mortality occurred at 0.4 pounds per acre in 1 day.	Mulla, et al (1963)
Guthion	*Carassius auratus* *Lepomis macrochirus* *Notemigonus crysoleucas*	BSCH	–	1.0 (O)* 0.1 (O)** 10.0 (O)* 1.0 (O)* 0.1 ? (O)* *response, 15 days **no response, 15 days	a c d e	Toxicity was determined by measuring acetylcholinesterase activity in the brains of fish. Concentrations are given in ppb as either response or not response in 15 or 30 days.	Weiss and Gakstatter (1964)
Guthion	*Gammarus lacustris*	BSA	–	0.000126 (T4A)	a e	Emulsible concentrates were prepared from technical grade insecticides with acetone as the solvent. Symptoms prior to death were observed and recorded on graphs.	Nebeker and Gaufin (1964)
Guthion	Bluegill	BSA	–	0.0052 (T4A)	a	Assays were conducted in soft water at 25 C. Decrease in brain cholinesterase was measured in fish exposed to the toxicant.	Weiss (1964)
Guthion	*Acroneuria pacifica* *Ephemerella grandis* *Gammarus lacustris* *Pteronarcys californica*	BSA	–	0.0085 (T4A) 0.014 (T4A) 0.00013 (T4A) 0.022 (T4A)	a c	Additional TL_m data are given.	Gaufin, et al (1965)
Guthion	*Pteronarcys californica* *Acroneuria pacifica* *Ephemerella grandis* *Gammarus lacustris*	BSA	–	0.02 (T4A) 0.009 (T4A) 0.01 (T4A) 0.0001 (T4A)	a	Unspecified chemical characteristics of assay water were determined by standard methods. General comments were made concerning "standardized" conditions, use of "soft" water, and use of emulsifying agents. Additional data are presented.	Gaufin, et al (1965)

Guthion (25% WP)	*Ictiobus cyprinellus* *Ictalurus puntatus* *Lepomis cyanellus* *Rana catesbeiana* *Notemigonus crysoleucas* *Lepomis macrochirus* *Micropterus salmoides*	BSA	–	(O) 9.0 (T2A) 9.0 (T2A) 0.025 (T2A) (O) 0.10 (T2A) 0.025 (K2) 0.025 (T2A)	a c d e	At 1.0 ppm concentration, bullfrog tadpoles and bigmouth buffalo were not affected. The compound performed effectively under various water conditions which included water from a bayou, lake, and in ponds filled with well water. 1.0 ppm of Guthion effectively controlled green sunfish without apparent effect on channel catfish.	Meyer (1965)
Guthion (tech, 95 percent active in acetone)	*Pteronarcys californica* (naiad) *Acroneuria pacifica* (naiad)	BSA	–	0.0220 (T4A) 0.0085 (T4A)	c d e f	*A. pacifica* was much more sensitive to chlorinated hydrocarbons and to organic phosphate insecticides than *P. californica*.	Jensen and Gaufin (1966)
Guthion	*Acroneuria pacifica* *Pteronarcys californica*	BSA & CFCH	–	0.0085 (T4A) 0.00024 (T30CH) 0.022 (T4A) 0.0013 (T30CH)	a c d e	Additional data are presented.	Jensen and Gaufin (1966)
Guthion	*Lepomis gibbosus*	BSA	–	1/4 (O)	–	The figures given are for mortality in 2 hours when the amount of chemical was 16 mg/kg, given by injection.	Murphy (1966)
Guthion	*Lepomis gibbosus* *Ictalurus melas* *Pseudopleuronectes americanus* *Myoxocephalus scorpius*		–	8.74 ± 1.72 (O) 3.64 ± 0.67 (O) 11.24 ± 1.60 (O) 0.03 ± 0.01 (O)	–	This paper is a study of the amounts of organic thiophosphate and their oxygen analogues which accumulate in liver slices in an *in vitro* study of insecticides. The numbers given are for m μm of chemical (in the case of Parathion, Malathion, and Guthion – the oxygen analogue) accumulated in 100 mg (dry weight) of liver in 30 minutes.	Murphy (1966)
Guthion	*Leiostromus xanthurus* *Cyprinodon variegatus*	BCFCH	–	0.01 (O) 0.01 (O)	a	At a concentration of 0.01 ppm, the following percent acetylcholinesterase activity as compared to controls was found: *L. xanthurus* – 79 *C. variegatus* – <10.	Butler and Johnson (1967)
Guthion (EC2)	*Micropterus salmoides*	BSA	–	1.0 (O) 1.50 (K1)	a e	At 10 ppm no mortality occurred in 1 day. Experiments were carried out in fiber glass tubs filled with well water. Fish weights ranged from 2 to 6 pounds.	Mulla, et al (1967)
Guthion	*Pteronarcys californica* (naiads)	BSA	–	0.0015 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Guthion	*Lepomis gibbosus* *Ictaluras melas* *Micropterus dolomieui* *Myxocephalus scorpius* *Pseudopleuronectes americanus*	BSA	—	(O)	a p	The chemicals were poor inhibitors of brain cholinesterases *in vitro*; their oxygen analogs were potent inhibitors.	Murphy, et al (1968)
Gutoxon	*Lepomis gibbosus* *Ictalurus melas* *Pseudopleuronectes americanus* *Myxocephalus scorpius*		—	0.205 ± 0.010 (O) 0.101 ± 0.044 (O) 0.039 ± 0.030 (O) 0.109 ± 0.020 (O)	—	This paper is a study of the amounts of organic thiophosphate and their oxygen analogues which accumulate in liver slices in an *in vitro* study of the insecticides. The numbers given are for mμm of the chemical accumulated in 50 mg of liver (wet weight) in 10 minutes.	Murphy (1966)
Gutoxon	*Lepomis gibbosus*	BSA	—	4/4 (O)	—	The figures given are for mortality in 2 hours when the amount of chemical was 1.0 mg/kg, given by injection.	Murphy (1966)
HCA	*Panicum hemitomum* *Pontederia cordata* Spatterdock	FL	Fla.	(O)	—	The degree of control was as follows: *P. hemitomum* (80 lb/acre) — 85 percent *P. cordata* (80 lb/acre) — 85 percent spatterdock (160 lb/acre) — none.	Copeland and Woods (1959)
Hept	Channel catfish (fingerlings)	BSA	—	12.4 (K 25 hr A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Heptachlor	Various	FL	Salt Lake Co., Utah	(O)	—	The chemical was applied at 0.1 lb/acre. At the above concentration no ill effects were observed in mammals, birds, reptiles, and amphibians. Invertebrates were not affected uniformly. Crustaceans were not harmed, nor were larvae of the insect family Ephydridae. Spiders and aquatic insects other than Ephydridae were adversely affected in varying degrees. Aquatic beetles seemed to be affected more seriously than other insects excepting mosquito larvae.	Graham and Anderson (1958)

Heptachlor	*Dorosoma cepedianum* *Esox americanus* *Erimyzon bucetta* *Notemigonus crysoleucas* *Opsopoeodus emiliae* *Ictalurus melas* *Fundulus chrysotus* *Gambusia affinis* *Aphredoderus sayanus* *Micropterus salmoides* *Chaenobryttus coronarius* *Lepomis symmetricus* *L. megalotis* *L. macrochirus* *Pomoxis nigromaculatus* *Etheostoma gracile*	FR	Texas	(O)	—	Experiments were conducted in fish streams and canals which bisect a farm treated with 10% Heptachlor at the rate of 20 pounds per acre to control fire ants. Fish were showing symptoms of distress 3 days after application of the Heptachlor. In a depression filled with water in a rice field 100% kill was noted for *Gambusia* and bantam sunfish (the most abundant species). There was no effect on tadpoles.	Boudreaux, et al (1959)
Heptachlor	Fathead minnow	BSA	—	0.094 (T4A)	a	It was the authors opinion that pH, alkalinity and hardness, within the usual range in natural waters, had little effect on the toxic effect of the compounds studied. The values given are from Henderson, Pickering, and Tarzwell, "The Relative Toxicity of Ten Chlorinated Hydrocarbon Insecticides to Four Species of Fish". It is interesting that the different tables from the above book (as reported in this paper) report widely different values for the same compounds. This experiment was performed in soft water.	Tarzwell (1959)
	Bluegill			0.019 (T4A)			
	Goldfish			0.230 (T4A)			
	Guppy			0.170 (T4A)			
Heptachlor	Fathead minnow	BSA	—	0.056 (T4A)	a	Comment same as above except that this experiment was performed in hard water.	Tarzwell (1959)
Heptachlor (25%)	Channel catfish (fingerlings)	BSA	—	1.8 (K 24 hr A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Heptachlor	*Pimephales promelas*	BSA	—	0.09 (T4A)	a d e f	Concentrations were based on percent active ingredient.	Henderson, et al (1959)
	Lepomis macrochirus			0.02 (T4A)			
	Carassius auratus			0.23 (T4A)			
	Lebistes reticulatus			0.11 (T4A)			

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Heptachlor (72%)	*Pimephales promelas*	BSA	–	0.18 (T4A)	a b e c d f	Dilution water was usually soft although some studies were conducted with hard water.	Henderson, et al (1959)
	Lepomis macrochirus			0.026 (T4A)			
	Carassius auratus			0.320 (T4A)			
	Lebistes reticulatus			0.148 (T4A)			
Heptachlor	*Pimephales promelas*	BSA	–	0.094 (T4A)	a	Bioassay investigations of the new insecticides indicate that in general the organic phosphorus compounds are not as toxic to fish as are the chlorinated hydrocarbons. The toxicity of most of these materials was not significantly influenced by water quality. Therefore it is to be expected that the toxicity of these materials will not differ significantly in different streams.	Tarzwell (1959)
	Lepomis macrochirus			0.019 (T4A)			
Heptachlor	*Daphnia magna*	BSA	–	0.05777 (O)	a	The indicated concentration immobilized *Daphnia* in 50 hours.	Anderson (1960)
Heptachlor	*Oncorhynchus kisutch*	BSA	–	59.0 (T4A)	a c d e	Chemical dissolved in acetone. TL_m expressed in PPB.	Katz (1961)
	Oncorhynchus tshawytscha			17.3 (T4A)			
	Salmo gardnerii			19.4 (T4A)			
	Gasterosteus aculeatus			111.9 (T4A)			
Heptachlor (heptachloro-4,7-methano-tetrahydro-indene)	*Richardsonius balteatus hydroflox*	BSA	–	>0.13 (T1A) 0.11 (T2A) 0.096 (T4A)	a c d e f	Results given were in soft water. Results in hard water were as follows: 0.15 (T1A), 0.12 (T2A), and 0.11 (T4A).	Webb (1961)
Heptachlor	*Lepomis microlophus*	BSA	–	0.02-0.09 (T1A)	a	This is a time-temperature study with considerable additional data presented.	Brown (1961)
Heptachlor	*Gammarus lacustris lacustris*	BSA	–	(O)	a e p	The mortality might have been partially due to the susceptibility of the organism to higher temperatures, toxicity from extended exposure to copper electrodes (used to shock the organism to determine death), or the increase of CO_2. Results were expressed as LT_{50}; for example, at 0.5 ppm, 50 percent of the shrimp were killed in 240 (±30) min.	McDonald (1962)
Heptachlor	*Salmo gairdneri*	BSA	–	150 (T1A) 90 (T2A) 70 (T4A)	a	The experiments were conducted at 55 F. Fish were 2-3 in. long.	Cope (1963)
	Radear sunfish			0.082 (T1A) 0.064 (T1A) 0.047 (T1A) 0.034 (T1A) 0.022 (T1A)		The experiment was conducted at 45 F. The experiment was conducted at 55 F. The experiment was conducted at 65 F. The experiment was conducted at 75 F. The experiment was conducted at 85 F. Higher temperatures caused a moderate increase in toxic effects.	

Heptachlor	*Lepomis cyanellus* *Lepomis macrochirus* *Rana catesbeiana*	FL	Miss.	(O)	–	Limited mortality of fish and amphibians occurred as a result of Heptachlor applications used to control fire ants. At a concentration of 2.0 (lb/acre) only one bullfrog was killed during the entire study. At a concentration of 0.25 plus 0.25 lb/acre (2 applications approximately 4 months apart) there were 8 dead green sunfish.	Ferguson (1963)
Heptachlor (EC2)	*Gambusia affinis* *Rana catesbeiana* (tadpoles)	FL	Cal.	0.5 (O)	a c	Mixed populations of the indicated test species contained in cages were exposed to various insecticidal chemicals applied as dilute sprays to ponds 1/16 acre in size. The indicated toxicant concentration is in lb/acre, and resulted in a 28 percent mortality for the fish, and a 50 percent mortality for the tadpoles in 24 hours.	Mulla (1963)
Heptachlor	*Gambusia affinis affinis*	BSA	–	0.07 to 1.3 (O)	a	The lower value is for fish that had never been exposed to the toxicant, and the higher value was obtained with fish that had been exposed to a sublethal dose in the past. Apparently such an exposure produces a resistance that can be retained when they are later placed in clean water.	Boyd and Ferguson (1964)
Heptachlor	Bluegill	BSA	–	0.019 (T4A)	a	Assays were conducted in soft water at 25 C. Decrease in brain cholinesterase was measured in fish exposed to the toxicant.	Weiss (1964)
Heptachlor (tech)	Rainbow trout	BSA	–	0.008 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
Heptachlor	*Salmo gairdneri* *Lepomis macrochirus* *Pteronarcys californica* *Baetis* sp *Daphnia pulex* *Simocephalus serrulatus*	BSA	–	0.009 (T2A) 0.026 (T2A) 0.006 (T2A) 0.032 (T2A) 0.042 (T2A) 0.047 (T2A)	a	This paper reports acute toxicity of a number of compounds, and discusses sub-acute mortality as well. Effects on reproduction and behavior are also discussed. Data presented as EC_{50}.	Cope (1966)
Heptachlor	*Simocephalus serrulatus* *Daphnia pulex*	BSA	–	0.047 (SB) 0.042 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 48 hr. Data cited are for 60 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
Heptachlor	*Daphnia carinata*	BSA	–	0.02 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Heptachlor	*Mya arenaria* *Crassostrea virginica* *Corbicula manillensis* *Mercenaria mercenaria* *Rangia cuneata*	BCFCH	–	(O)	–	Results are recorded as a range of uptake of the chemical by 5 species of aquatic mollusks. An uptake or concentration of 250-2500X resulted.	Butler (1967)
Heptachlor	Oyster	FE	Galveston Bay, Texas	(O)	–	The chemical was found in the water at a concentration of <0.001 ppm. Oysters from the area were found to contain <0.01 ppm.	Casper (1967)
Heptachlor	*Micropterus salmoides salmoides* *Lepomis macrochirus* *Chelydra serpentine*	FL	Va.	(O)	–	The amount of chemical applied was not specified in this report. None of the chemical was found in the tissues of either bass or bluegill taken from polluted ponds. However, a snapping turtle taken from a pond that had no residue of chemical in the water or bottom mud was found to contain 5100 ppb in the body fat, egg yolk, and liver tissues.	Weatherholtz, et al (1967)
Heptachlor	*Pteronarcys californica* (naiads)	BSA	–	0.0011 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
	Pteronarcella badia (naiads)			0.0009 (T4A)			
	Claassenia sabulosa (naiads)			0.0028 (T4A)			
Heptachlor	*Alosa pseudoharengus* *Aplodinotus grunniens* *Coregonus artedii* *Lota lota*	BSA	–	(O)	–	The study showed that the levels of chlorinated hydrocarbon pesticide residues in fish meals and oils were, with the exception of the oil sample taken from the Lake Michigan alewife, below the regulatory tolerances established by the Food and Drug Directorate of Canada (1965) for certain foods intended for human consumption. Pesticide levels were interpreted as being representative for each species.	Dugal (1968)
Heptachlor epoxide	*Buteo buteo* *Accipiter gentilis* *Accipiter nisus* *Falco tinnunculus* *Tyto Alba*	FO	Netherlands	(O)	–	The results of this study show that birds of prey and fish-eating birds found dead in the Netherlands accumulated large amounts of different chlorinated hydrocarbon insecticides. In most cases the liver had the highest concentration of toxicant, ranging from 0.07 to 4.7 ppm. Most chlorinated hydrocarbons tend to accumulate in the fat depots of the body. In instances where mesenterial fat was found the concentration of toxicant was found to be as high as 3.0 ppm.	Koeman and van Genderen (1966)

Heptachlor epoxide	*Strix aluco* *Osio otus* *Falco peregrinus* *Alosa pseudoharengus* *Aplodinotus grunniens* *Coregonus artedii* *Lota lota*	BSA	–	(O)	–	The study showed that the levels of chlorinated hydrocarbon pesticide residues in fish meals and oils were, with the exception of the oil sample taken from the Lake Michigan alewife, below the regulatory tolerances established by the Food and Drug Directorate of Canada (1965) for certain foods intended for human consumption. Pesticide levels were interpreted as being representative for each species.	Dugal (1968)
Hercules 528	*Lepomis macrochirus*	BSA	–	0.1 (O)	a c d f	This paper reports the effect of insecticides in reducing the anticholinesterase in a fish brain within 2-8 hours. The inhibition of the enzyme was a function of the concentration of the insecticide, extent of exposure, and specific chemical nature of the compound.	Weiss (1959)
	Micropterus salmoides			0.1 (O)			
	Notemigonus crysoleucas			0.1 (O)			
	Carassius auratus			0.1 (O)			
Hercules 3895 G	*Gambusia affinis*	BSA	–	0.05 (K 0%)	a	Chemicals were dissolved in acetone, and tests were run in triplicate. Toxicity is given as average percent fish killed in 24 hours.	Lewallen (1959)
Hercules 7175 (tech)	*Lepomis macrochirus*	BSA	–	40,000 (T1A)	a	The experiment was conducted at 75 F. Fish weighed 0.4 g.	Cope (1963)
Hercules 7531 (tech)	*Lepomis macrochirus*	BSA	–	25,000 (T1A)	a	Comment same as above.	Cope (1963)
HRS-1622 (octachloropropane)	*Australorbis glabratus*	BSA and FL	Puerto Rico	Failed	c	Seven of the tested compounds failed to meet acceptability criteria – that is, complete kill after 6-hr exposure to 10 ppm. They were not used in field tests. Field tests showed WL 8008 to be highly effective.	Seiffer and Schoof (1967)
Hyamine	*Oncorhynchus kisutch*	BSA	–	57 (T1A) 53 (T2A)	a c d e	Concentrations were based on percent active ingredient.	Bond, et al (1960)
Hyamine 1622	*Lepomis macrochirus*	BSA	–	(S) 1.6 (T4A) (H) 3.8 (T4A)	a c e	Bioassay method in Standard Methods for examination of water was used. Both hard (H) and soft (S) water were used. TL_m values for 24 and 48 hr are also presented.	Surber and Pickering (1962)
	Pimephales promelas			(S) 1.6 (T4A) (H) 3.8 (T4A)			
Hyamine 2389	*Lepomis macrochirus*	BSA	–	(S) 1.2 (T4A) (H) 4.8 (T4A)	a c e	Comment same as above.	Surber and Pickering (1962)
	Pimephales promelas			(S) 2.4 (T4A) (H) 4.2 (T4A)			
Hydram	Oyster	BCF	–	(O)	a	No effect on exposure to the chemical at 1.0 ppm.	Butler (1965)
Hydram	*Penaeus aztecus*	L	–	(O)	a	Toxicant chemicals were evaluated in sea water at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality. A concentration of 1.0 ppm caused 10 percent mortality.	Butler (1965)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Hydram	*Leiostomus xanthurus* (juvenile)	BSA	–	(O)	a	Water temperature was 25 C. 20% mortality at 1.0 ppm.	Butler (1965)
Hydram	*Crassostrea virginica*	BCFA & BSA	–	1.0 (NTE)	–	Sea water was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
	Penaeus aztecus			1.0 (0, 30%)			
	Leiostomus xanthurus			1.0 (20% T2CFA)			
	Phytoplankton			9% (O)			
Hydram	*Pteronarcys* sp (nymphs)	BSA	–	0.370 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Hydram (tech)	Rainbow trout	BSA	–	0.200 (T4A)	a	This is an estimated LC_{50} value at temperatures from 55 to 75 F.	Cope (1965)
	Bluegill			0.355 (T4A)			
Hydram	*Salmo gairdneri*	BSA	–	0.290 (T2A)	a	This paper reports acute toxicity of a number of compounds, and discusses sub-acute mortality as well. Effects on reproduction and behavior are also discussed. Data presented as EC_{50}.	Cope (1966)
	Lepomis macrochirus			0.475 (T2A)			
	Pteronarcys californica			0.700 (T2A)			
Hydram (tech)	Rainbow trout	BSA	–	0.29 (T2A)	–	Data are given as LC_{50}.	Bohmont (1967)
	Bluegill			0.475 (T2A)			
Hydrothal 191	Rainbow trout	BSA	–	1.5 (T2A)	–	Comment same as above.	Bohmont (1967)
Hydrothal plus	*Lepomis macrochirus*	BSA	–	3.5 (T1A)	a b e	This report is a simple and straightforward determination of a median tolerable limit for a selected group of herbicides.	Hughes and Davis (1967)
Ibcol	Guppy	BSA	–	100 (K1)	a	Those fish that survived at lower concentrations were still very active several days after they had been taken out and placed in fresh water.	Anonymous (1964)
Imidan	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	–	4.0 (O)	a	Stones heavily populated with wild larvae were placed in troughs of running water containing the toxicant. When the larvae became detached from the rocks and floated away, they were assumed to have undergone lethal intoxication. The larvae were exposed to the toxicant for 5 minutes, then in clean water for 24 hours. At that time the number detached amounted to 85 percent.	Jamnback and Frempong-Boadu (1966)

Inverton (2,4,5-T)	*Nymphaea* sp Parrot feathers	FL	Farm ponds in Georgia	(O)	—	*Nymphaea* sp and parrot feathers were killed at the recommended application rate of one gallon Inverton mixed with 15 gallons of fuel, and 84 gallons of water per acre killed completely in less than a week.	Thomaston, et al (1959)
Iodophor	Guppy	BSA	—	6250 (K1)	a	Those fish that survived at lower concentrations were still very active several days after they had been taken out and placed in fresh water.	Anonymous (1964)
IPC 50%	Channel catfish (fingerlings)	BSA	—	>100 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
IPC (tech)	Bluegill	BSA?	—	29.0 (T4A)	a	This is an estimated LC_{50} value at temperatures from 55 to 75 F.	Cope (1965)
IPC	*Simocephalus serrulatus*	BSA	—	10.0 (SB)	—	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
	Daphnia pulex			10.0 (SB)			
IPC (tech)	Bluegill	BSA	—	32.0 (T2A)	—	Data are given as LC_{50}.	Bohmont (1967)
Isodrin (EC 1.6)	*Gambusia affinis*	FL	Cal.	0.5 (O)	a c	Mixed populations of the indicated test species contained in cages were exposed to various insecticidal chemicals applied as dilute sprays to ponds 1/16 acre in size. The indicated toxicant concentration is in lb/acre, and resulted in a 100 percent mortality for these fish.	Mulla (1963)
Isolan (EC2)	*Gambusia affinis*	FL	Cal.	2.0 (K1)	—	Toxicity value is in lb/acre.	Mulla (1966)
Isotex 25	Channel catfish (fingerlings)	BSA	—	0.54 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
K-6882 (25 percent EC)	*Gambusia affinis*	FL	Ponds — Bakersfield, Cal.	(O)	a c	No fish mortality occurred at 0.2 to 0.8 lb/acre rates of application. The experiments were conducted in cages placed in the ponds.	Mulla and Isaak (1961)
Karmex W_C [3-(p-chlorophenyl)-1,1-dimethylurea; 80% active ingredient]	*Richardsonius balteatus hydroflox*	BSA	—	42.5 (T1A) 41.5 (T2A) 41.5 (T4A)	a c d e f	Results given were in soft water. Results in hard water were as follows: 60.3+(T1A), 41.2 (T2A), and 40.1 (T4A).	Webb (1961)
Kelthane	*Salmo gairdneri*	BSA	—	110 (T1A)	a	The experiment was conducted at 55 F. Fish weighed 0.7 g.	Cope (1963)
Kelthane	*Gambusia affinis*	BSA	—	2.1 (L1)* 1.9 (L1)** *Resistant fish **Nonresistant fish	a	This paper deals with the resistance of mosquito fish to chlorinated hydrocarbon compounds. Resistant fish were not always less sensitive to these chemicals.	Boyd and Ferguson (1964)
Kepone	*Lepomis microlophus*	BSA	—	0.1-0.6 (T1A)	a	This is a time-temperature study with considerable additional data presented.	Brown (1961)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Kepone	*Lepomis macrochirus*	BSA	–	380 (T 18 hr) 240 (T 32 hr) 110 (T 56 hr)	a	The experiment was conducted at 65 F. Fish were 2 in. long.	Cope (1963)
	Redear sunfish			0.62 (T1A) 0.54 (T1A) 0.34 (T1A) 0.24 (T1A) 0.12 (T1A)		The experiment was conducted at 45 F. The experiment was conducted at 55 F. The experiment was conducted at 65 F. The experiment was conducted at 75 F. The experiment was conducted at 85 F. Higher temperatures caused a moderate increase in toxic effects.	
Kepone (EC 2)	*Gambusia affinis* *Rana catesbeiana* (tadpoles)	FL	Cal.	0.5 (O)	a c	Mixed populations of the indicated test species contained in cages were exposed to various insecticidal chemicals applied as dilute sprays to ponds 1/16 acre in size. The indicated toxicant concentration is in lb/acre, and resulted in a 18 percent mortality for the fish, and a 0 percent mortality for the tadpole in 24 hr.	Mulla (1963)
Kepone (tech)	Rainbow trout	BSA	–	0.020 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
Knoxweed 42	*Leiostomus xanthurus* (juvenile)	BSA	–	(O)	a	Water temperature was 25 C. No effect was noticed on exposure to 1.0 ppm.	Butler (1965)
Knoxweed 42	Oyster	BCF	–	(O)	a	Exposure to a concentration of 1 ppm caused a 44.0% decrease in shell growth.	Butler (1965)
Knoxweed 42	*Penaeus aztecus*	L	–	(O)	a	Toxicant chemicals were evaluated in sea water at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality. A concentration of 1.0 ppm caused 40 percent mortality.	Butler (1965)
Knoxweed 42	*Crassostrea virginica* *Penaeus aztecus* *Leiostomus xanthurus* Phytoplankton	BCFA & BSA	–	1.0 (O) 0.48 (O) 1.0 (NTE) 1.0 (NTE)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
Korlan	*Gambusia affinis*	BSA	–	0.1 (K 3%)	a	Chemicals were dissolved in acetone, and tests were run in triplicate. Toxicity is given average percent fish killed in 24 hr.	Lewallen (1959)

Kuron	*Najas quadalupensis* Spatterdock	FL	Fla.	(O)	—	At 20 lb/acre, *N. quadalupensis* was not controlled while 5-10 percent control of spatterdock was obtained.	Copeland and Woods (1959)
Kuron	*Onchorynchus tshawytscha* *Micropterus salmoides*	BSA	—	1.35 (T1A) 1.23 (T2A) 3.5 (T1A)	a c d e	Concentrations were based on percent active ingredient.	Bond, et al (1960)
Kuron (silvex acid equivalent)	*Micropterus salmoides* (fry)	BSA	—	1.0 (SB3)	a c d e f p	At least 90 percent of the fry survived for a period of 72 hours at the concentration listed.	Jones (1965)
	Ictalurus punctatus (fry)			0.5 (SB3)			
	Lepomis macrochirus (fry)			0.3 (SB3)			
Kuron	*Pteronarcys* sp (nymphs)	BSA	—	0.320 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Kuron	Chinook salmon Bluegill	BSA	—	1.35 (T1A) 1.23 (T2A) 2.9 (T1A) 2.4 (T2A)	a c d	Tests were conducted in glass jars holding 15 liters of water. Toxicity of Kuron varies with the supplier.	Bond, et al (1965)
Kuron	*Simocephalus serrulatus* *Daphnia pulex*	BSA	—	2.4 (SB) 2.00 (SB)	—	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
Kurosal	*Lepomis macrochirus*	BSA	—	120,000 (T1A)	a	The experiment was conducted at 75 F. Fish weighed 0.6 g.	Cope (1963)
Kurosal G	Bluegill	BSA	—	21 (T1A) 15 (T2A)	a c d	Tests were conducted in glass jars holding 15 liters of water.	Bond, et al (1965)
Kurosal G (silvex acid equivalent)	*Lepomis macrochirus* (fry)	BSA	—	150 (SB3)	a c d e f p	At least 90 percent of the fry survived for a period of 72 hours at the concentration listed.	Jones (1965)
Kurosal SL	*Oncorhynchus kisutch*	BSA	—	290 (T1A) 240 (T2A) 83 (T1A) 83 (T2A)	a c d	Tests were conducted in glass jars holding 15 liters of water. Active ingredient of Kurosal SL is silvex 2-(2,4,5-trichlorophenoxy) propionic acid, potassium salt.	Bond, et al (1965)
Kurosal SL (silvex acid equivalent)	*Lepomis macrochirus* (fry)	BSA	—	100 (SB3)	a c d e f p	At least 90 percent of the fry survived for a period of 72 hours at the concentration listed.	Jones (1965)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Kurosal SL (60% silvex)	*Crassostrea virginica*	BCFA & BSA	–	1.0 (NTE)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
	Fundulus similis			25.0 (NTE)			
	Phytoplankton			1.0 (NTE)			
Kyro-eo (nonionic)	Brook trout	BSA	–	5.2 (L1) 4.8 (L2) 4.6 (L3)	–	Kyro-eo is a synthetic, non-sulfonated detergent. Experimental water was not supplemented with oxygen because bubbling caused suds. Control tanks were also static. Control organisms apparently did not suffer from lack of oxygen in the static aquarium for 120 hr. Dipteran larvae withstood 10 ppm of Kyro-eo with no mortality.	Hepworth (no date)
	Rainbow trout			5.5 (L1) 5.3 (L2) 5.1 (L3)			
	Mayflies (Ephemeroptera naiads)			5.6 (L2) 5.4 (L3) 5.2 (L4)			
	Stoneflies (Plecoptera naiads)			5.1 (L2) 4.8 (L3) 4.7 (L4)			
	Damsel flies (Odonata naiads)			5.2 (L3) 4.9 (L4)			
	Diptera larva (chiefly Tendipedidae)			(O)			
LAS (degradation product–sulfophenylundecanoic acid, disodium salt)	Bluegill (fingerlings)	BSA	–	75.0 (T4A)	c d e f o	The fish killed all showed severe hematomas of the respiratory folds of the gills. This was followed by the stripping of the mucous layers. Following this, soft tissue beneath was completely destroyed in most cases.	Swisher, et al (1964)
LAS C 12 (alkylbenzene sodium sulfonate)	Bluegill (fingerlings)	BSA	–	3.0 (T4A)	c d e f o	Comment same as above.	Swisher, et al (1964)
LAS C 14 (alkylbenzene sodium sulfonate)	Bluegill (fingerlings)	BSA	–	0.64 (T4A)	c d e f o	Comment same as above.	Swisher, et al (1964)

LAS	*Pimephales promelas* (eggs)	BCF	–	2.3 (T4A)	a c d e f	Mortality range is given for exposure (days 1-9) with various concentrations and controls. Additional data are presented.	Pickering (1966)
Linear alkyl sulfonate	*Lepomis macrochirus* *Pimephales promelas* *Ictalurus melas* *Notropis atherinoides* *Notropis cornutus*	BSA	–	4.0 (T4A) 4.2 (T4A) 6.4 (T4A) 3.3 (T4A) 4.9 (T4A)	a c d e	In all these tests the LAS stock powder contained 50.8% LAS. The values reported were calculated on a basis of pure LAS.	Thatcher and Santner (1967)
Lethane 384	*Prosimulium* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	–	4.0 (O)	a	Stones heavily populated with wild larvae were placed in troughs of running water containing the toxicant. When the larvae became detached from the rocks and floated away, they were assumed to have undergone lethal intoxication. The larvae were exposed to the toxicant for 5 minutes, then in clean water for 24 hours. At that time the number detached amounted to 2 percent.	Jamnback and Frempong-Boadu (1966)
Lexone	Channel catfish (fingerlings)	BSA	–	5.2 (K 30 hr A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Lignasan	Channel catfish (fingerlings)	BSA	–	2.0 (K 28 hr A)	a	Comment same as above.	Clemens and Sneed (1959)
Lignasan	*Protococcus* sp *Chlorella* sp *Dunaliella euchlora* *Phaeodactylum tricornutum* *Monochrysis lutheri*	BSA	–	0.006 (K) 0.006 (K) 0.06 (K) 0.06 (K) 0.006 (K)	a	This paper concerns the growth of pure cultures of marine plankton in the presence of toxicants. Results were expressed as the ratio of optical density of growth in the presence of toxicants to optical density in the basal medium with no added toxicants.	Ukeles (1962)
Lindane	Fathead minnow Bluegill Goldfish Guppy	BSA	–	0.062 (T4A) 0.077 (T4A) 0.152 (T4A) 0.138 (T4A)	a	It was the authors opinion that pH, alkalinity and hardness, within the usual range in natural waters, had little effect on the toxic effect of the compounds studied. The values given are from Henderson, Pickering, and Tarzwell, "The Relative Toxicity of Ten Chlorinated Hydrocarbon Insecticides to Four Species of Fish". It is interesting that the different tables from the above book (as reported in this paper) report widely different values for the same compounds. This experiment was performed in soft water.	Tarzwell (1959)
Lindane	Fathead minnow	BSA	–	0.056 (T4A)	a	Comment same as above, except experiment was conducted in hard water.	Tarzwell (1959)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Lindane 3% (Methoxychlor 50%)	Channel catfish (fingerlings)	BSA	–	2.0 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Lindane	*Pimephales promelas*	BSA	–	0.06 (T4A)	a d e f	Concentrations were based on percent active ingredient.	Henderson, et al (1959)
	Lepomis macrochirus			0.09 (T4A)			
	Carassius auratus			0.15 (T4A)			
	Lebistes reticulatus			0.14 (T4A)			
Lindane (100%)	*Pimephales promelas*	BSA	–	0.062 (T4A)	a b e c d f	Dilution water was usually soft although some studies were conducted with hard water.	Henderson, et al (1959)
	Lepomis macrochirus			0.077 (T4A)			
	Carassius auratus			0.152 (T4A)			
	Lebistes reticulatus			0.138 (T4A)			
Lindane	*Pimephales promelas*	BSA	–	0.062 (T4A)	a	Bioassay investigations of the new insecticides indicate that in general the organic phosphorus compounds are not as toxic to fish as are the chlorinated hydrocarbons. The toxicity of most of these materials was not significantly influenced by water quality. Therefore it is to be expected that the toxicity of these materials will not differ significantly in different streams.	Tarzwell (1959)
	Lepomis macrochirus			0.077 (T4A)			
Lindane	*Oncorhynchus kisutch*	BSA	–	50.0 (T4A)	a c d e	Chemical dissolved in acetone. TL_m expressed in ppb.	Katz (1961)
	Oncorhynchus tshawytscha			40.0 (T4A)			
	Salmo gairdnerii			38.0 (T4A)			
	Gasterosteus aculeatus			44.0 (T4A)			
Lindane	*Gammarus lacustris lacustris*	BSA	–	(O)	a e p	The mortality might have been partially due to the susceptibility of the organism to higher temperatures, toxicity from extended exposure to copper electrodes (used to shock the organism to determine death), or the increase of CO_2. Results were expressed as LT_{50}; for example, at 0.5 ppm, 50 percent of the shrimp were killed in 11 (±2) min.	McDonald (1962)

Lindane	*Protococcus* sp *Chlorella* sp *Dunaliella euchlora* *Phaeodactylum tricornutum* *Monochrysis lutheri*	BSA	–	9.0 (O)* 9.0 (O)* 9.0 (O) 9.0 (NG) 7.5 (NG) *obvious, but inhibited growth	a	This paper concerns the growth of pure cultures of marine plankton in the presence of toxicants. Results were expressed as the ratio of optical density of growth in the presence of toxicants to optical density in the basal medium with no added toxicants. NG = no growth, but the organisms were viable.	Ukeles (1962)
Lindane	*Ophicephalus punctatus* *Heteropneustes fossilis* *Barbus stigma* *Trichogaster fasciatus*	BSA	–	4000-5000 (K < 1 hr) 2000-5000 (K < 7 hr) 1000 (K < 2 hr) 2000-3000 (K < 1 hr)	a	The dosage to produce toxic symptoms varied with each species. At the very low dosage, these insecticides did not produce observable changes, but at the higher dosage observable changes were pronounced. Lindane at low concentrations had no noticeable effect but at higher concentrations the rate or mortality was very high.	Mathur (1963)
Lindane	Golden shiner	BSA	–	>0.062-0.125 (O)	a c d e p	A number of values for a threshold limit (LD/O) of the toxicant in various solvents are given. Values from 0.062 ppm to 0.125 ppm for Lindane solvents in addition to water were obtained. Acetone and mixed solvents caused the greatest Lindane lethality.	Meyer (1965)
Lindane EC 1.65	*Rana catesbeiana* (tadpoles)	FL	Cal.	0.5 (O)	a c	Mixed populations of the indicated test species contained in cages were exposed to various insecticidal chemicals applied as dilute sprays to ponds 1/16 acre in size. The indicated toxicant concentration is in lb/acre, and resulted in a 10 percent mortality for the tadpoles in 24 hr.	Mulla (1963)
Lindane	*Gambusia affinis affinis*	BSA	–	0.15 to 1.7 (O)	a	The lower value is for fish that had never been exposed to the toxicant, and the higher value was obtained with fish that had been exposed to a sublethal dose in the past. Apparently such an exposure produces a resistance that can be retained when they are later placed in clean water.	Boyd and Ferguson (1964)
Lindane (tech)	Rainbow trout	BSA	–	0.022 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
Lindane	*Pteronarcys* sp (nymphs)	BSA	–	0.001 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Lindane	Bluegill	BSA	–	65 (T4A) 53 (T4A) 56 (T4A) 38 (T4A) 25 (T4A)	a	These experiments were performed to demonstrate that at increased temperatures the toxic effect of most chemicals is increased. For the toxicant concentrations listed, the temperatures were respectively, 45, 55, 65, 75, and 85 F. Data on the effect of time as well as temperature was also reported. The experimental animals all were approximately one gram in weight.	Cope (1965)
Lindane	*Pteronarcys* (stone fly nymphs)	BSA	–	0.001 (T4)	a	These experiments were all conducted at 60 F. The values were listed as LC_{50}.	Snow (1958)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Lindane	*Salmo gairdnerii*	BSA	–	0.022 (T2A)	a	This paper reports acute toxicity of a number of compounds, and discusses subacute mortality as well. Effects on reproduction and behavior are also discussed. Data presented as EC_{50}.	Cope (1966)
	Lepomis macrochirus			0.053 (T2A)			
	Pteronarcys californica			0.002 (T2A)			
	Daphnia pulex			0.460 (T2A)			
	Simocephalus serrulatus			0.520 (T2A)			
Lindane	*Buteo buteo* *Accipiter gentilis* *Accipiter nisus* *Falco tinnunculus* *Tyto alba* *Strix aluco* *Asio otus* *Falco pereginus*	FO	Netherlands	(O)	–	The results of this study show that birds of prey and fish-eating birds found dead in the Netherlands accumulated large amounts of different chlorinated hydrocarbon insecticides. Most chlorinated hydrocarbons tended to accumulate in the fat depots of the body. In instances where mesenterial fat was analyzed the concentration of toxicant was found to be as high as 89 ppm.	Koeman and van Genderen (1966)
Lindane	*Puntius javanicus*	FL	Japan	1.0% (O) 4.0% (O)	–	No fish deaths occurred at the 1.0 percent concentration. The following mortality occurred at the 4.0 percent level: *P. javanicus* – 56.5 percent (2 days) *T. mossambica* – 86.0 percent (2 days) *C. carpio* – 7.5 percent (2 days)	Kok and Pathak (1966)
	Tilapia mossambica			1.0% (O) 4.0% (O)			
	Cyprinus carpio			1.0% (O) 4.0 % (O)			
Lindane	*Puntius javanicus*	BSA	–	2.0 (K2)	e	The purpose of this experiment was to determine the effect of Lindane on three species of fish. The Lindane was Dol granule, a granular formulation containing 6 percent Lindane and 94 percent carrier. With *C. carpio*, the 2.0 ppm killed 77.5 percent of the test fish in 2 days. The data given are concerned with exposure in water solutions. When soil was added to the water, the mortality was reduced.	Kok and Pathak (1966)
	Tilapia mossambica			2.0 (K2)			
	Cyprinus carpio			2.0 (0)			
Lindane	*Simocephalus serrulatus*	BSA	–	0.520 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 48 hr. Data cited are for 60 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
	Daphnia pulex			0.460 (SB)			

Lindane	*Daphnia magna*	BSA	–	1.1 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
Lindane	*Mya arenaria* *Crassostrea virginica* *Corbicula manillensis* *Mercenaria mercenaria* *Rangia cuneata*	BCFCH	–	(O)	–	Results are recorded as a range of uptake of the chemical by 5 species of aquatic mollusks. An uptake or concentration of 10-250X resulted.	Butler (1967)
Lindane	Oyster	FE	Galveston Bay, Texas	(O)	–	The chemical was found in the water at a concentration of <0.001 ppm. Oysters from the area were found to contain <0.01 to 0.01 ppm.	Casper (1967)
Lindane-C14	*Lepomis macrochirus* *Carassius auratus*	BCFCH	–	(O)	a	Fish were treated with carbon-labeled insecticides (0.03 ppm) from 5 to 19 hr and uptake rates were determined. They were placed in recovery tanks for up to 32 days. Whole body samples were then made. Almost all of Lindane absorbed was eliminated in 2 days.	Gakstatter and Weiss (1967)
Lindane	*Esox lucius*	FR	River Nene, Eng.	(O)	–	Higher concentrations were found in larger fish, indicating that they had been exposed to the pesticides for a longer time. Tissue extracts from the pike were analyzed for organochlorine pesticide residues by gas liquid chromatography. The values for large pike were: 0.042 ppm muscle 7.5 ppm fat	Mawdesley-Thomas and Leahy (1967)
M-502	*Althemanthera philoxeroides* *Pistia stratiotes* Spatterdock	FL	Fla.	(O)	–	At 1.0 lb/acre, the degree of control was: *A. philoxeroides* – 85-90 percent *P. stratiotes* – 80 percent spatterdock – 3 percent	Copeland and Woods (1959)
M-1499 (granular Silvex)	Bushy pondweed Water Hyssop Parrot's Feather Bladderwort	FL	Lakes in Fla.	(O)	–	Concentrations of 2.3 to 2.5 ppm controlled bushy pondweed while 1.0 to 4.0 ppm controlled the other species indicated.	Phillippy (1961)
M-1500	Bushy pondweed	FL	Lakes in Fla.	(O)	–	A concentration of 1.5 ppm controlled bushy pondweed.	Phillippy (1961)
M-1845 (liquid Silvex)	Spatterdock Bushy pondweed	FL	Lakes in Fla.	(O)	–	A concentration of 0.5 ppm controlled the spatterdock while 1.0 ppm per acre controlled the bushy pondweed.	

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
MCP (Amine)	*Crassostrea virginica* *Penaeus aztecus* *Fundulus similis* Phytoplankton	BCFA & BSA	–	1.0 (NTE)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
MCPA (alkyl amine)	*Lepomis macrochirus*	BSA	–	163.5 (T1A)	–	The bioassay methods employed in this experiment were not given in the paper but it was stated that the same procedures were employed as in previous work.	Davis and Hughes (1963)
MCPA	*Lepomis macrochirus*	BSA	–	1.5 (T1A)	a b e	This report is a simple and straightforward determination of a median tolerance limit for a selected group of herbicides.	Hughes and Davis (1967)
MCPA	*Daphnia magna*	BSA	–	100 (O)	a c d i q	Toxicity, in terms of median immobilization concentration (IC_{50}), is presented.	Crosby and Tucker (1966)
4-(MCPB)	*Lepomis macrochirus*	BSA	–	15 (T2A)	a c o	The response of bluegill and bass fingerlings to nine agricultural chemicals as determined by bioassay using river water is presented in this report. Bluegills were more tolerant of the chemicals tested than bass.	Davis and Hardcastle (1959)
	Micropterus salmoides			10 (T2A)			
Malamar-50	*Cyprinus carpio*	BSA	–	10.0 (T2A)	a c d e f p	The test animals were conditioned for 48 hours prior to use.	Sreenivasan and Swaminathan (1967)
	C. carpio			8.5 (T2A)			
	Tilapia mossambica			8.3 (T2A)			
	Cirrhina mrigala			7.0 (T2A)			
	Labeo fimbriatus			8.5 (T2A)			
	Danio sp			13.5 (T2A)			
	Labeo rohita			8.0 (T2A)			
Malaoxon	*Lepomis gibbosus*	BSA	–	2/4 (O)	–	The figures given are for mortality in 2 hours when the amount of chemical was 0.25 mg/kg, given by injection.	Murphy (1966)
Malaoxon	*Lepomis gibbosus*	L	–	1.59 ± 0.17 (O)	–	This paper is a study of the amounts of organic thiophosphate and their oxygen analogues which accumulate in liver slices in an *in vitro* study of the insecticides. The numbers given are for mμm of the chemical accumulated in 50 mg of liver (wet weight) in 10 minutes.	Murphy (1966)
	Ictalurus melas			0.97 ± 0.28 (O)			
	Pseudopleuronectes americanus			0.81 ± 0.09 (O)			
	Myxocephalus scorpius			1.27 ± 0.14 (O)			
Malathion (25 percent wettable powder)	*Cyprinus carpio*	BSA	–	(O)	a c e	100 percent mortality occurred in 6 days at 5 ppm. 90 percent mortality occurred in 4 days at 7 ppm.	Hayes (1955)
Malathion (emulsifiable)	*Cyprinus carpio*	BSA	–	(O)	a c e	60 percent mortality occurred in 143 hr at 3 ppm. 0 percent mortality occurred in 4 days at 0.01 ppm. 0 percent mortality occurred in 140 hr at 1 ppm. 100 percent mortality occurred 117 hr at 7 ppm.	Hayes (1955)

Malathion	Fall chinook salmon (fingerlings)	BSA	–	0.17 (T1A) 0.15 (T2A) 0.12 (T4A)	a	At 0.32 ppm there were no survivals after 48 hours.	Parkhurst and Johnson (1955)
Malathion	Various	FL	Salt Lake Co., Utah	(O)	–	The chemical was applied at 0.5 lb/acre. At the above concentration no ill effects were observed in mammals, birds, reptiles, and amphibians. Invertebrates were not affected uniformly. Crustaceans were not harmed, nor were larvae of the insect family Ephydridae. Spiders and aquatic insects other than Ephydridae were adversely affected in varying degrees. Aquatic beetles seemed to be affected more seriously than other insects excepting mosquito larvae.	Graham and Anderson (1958)
Malathion	*Pimephales promelas*	BSA	–	22.0 (T4A)	a c d e f	Tests were performed in both hard and soft water. Additional tolerance limit values are given.	Henderson and Pickering (1958)
Malathion	Atlantic salmon	BSA	–	0.033 (T1A) 0.033 (T2A)	a e	Results are recorded in ppm of insecticide by weight in water. Changes in temperature had an effect on the toxicity of the chemical.	Keenleyside (1958)
Malathion	Fathead minnow	BSA	–	12.5 (T4A)	a	It was the authors opinion that pH, alkalinity and hardness, within the usual range in natural waters, had little effect on the toxic effect of the compounds studied. The values given are from Henderson, Pickering, and Tarzwell, "The Relative Toxicity of Ten Chlorinated Hydrocarbon Insecticides to Four Species of Fish". It is interesting that the different tables from the above book (as reported in this paper) report widely different values for the same compounds. The experiment was performed in hard water.	Tarzwell (1959)
Malathion	*Daphnia magna*	BSA	–	0.0009 (O)	a	The indicated concentration immobilized *Daphnia* in 50 hours.	Anderson (1960)
Malathion 25%	Channel catfish (fingerlings)	BSA	–	>100 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Malathion	*Fundulus ocellaris*	FL(E)	Odessa, Del.	(O)	–	The extent of mortality at an application rate of 0.5 lb/acre in tidal marshes while another 33% of the fish were not affected at all. The fate of those individuals that were poisoned, but remained alive, is in question. The tests indicated that 56% would recover if transferred to fresh water following the exposure period.	Darsie and Corriden (1959)
Malathion	*Pimephales promelas*	BSA	–	12.5 (T4A)	a d e f	Concentrations were based on percent active ingredient.	Henderson, et al (1959)
Malathion	*Gambusia affinis*	BSA	–	0.05 (K 40%)	a	Chemicals were dissolved in acetone, and tests were run in triplicate. Toxicity is given as average percent fish killed in 24 hr.	Lewallen (1959)
Malathion	*Pimephales promelas* *Lepomis macrochirus*	BSA	–	17 (T4A)	a	Bioassay investigations of the new insecticides indicate that in general the organic phosphorus compounds are not as toxic to fish as are the chlorinated hydrocarbons. The toxicity of most of these materials was not significantly influenced by water quality. Therefore it is to be expected that the toxicity of these materials will not differ significantly in different streams.	Tarzwell (1959)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Malathion	*Lepomis macrochirus*	BSA	–	0.1 (O)	a c d f	This paper reports the effect of insecticides in reducing the anticholinesterase in a fish brain within 2-8 hours. The inhibition of the enzyme was a function of the concentration of the insecticide, extent of exposure, and specific chemical nature of the compound.	Weiss (1959)
	Micropterus salmoides			0.1 (O)			
	Notemigonus crysoleucas			0.1 (O)			
	Carassius auratus			0.1 (O)			
Malathion (tech, 57% active in xylene)	*Acroneuria pacifica*	BSA	–	0.0056 (T4A)	a c e f l n	Assays were conducted in hard water.	Gaufin (1961)
	Pteronarcys californica			0.1 (T4A)			
	Claassenia sabulosa			0.056 (T4A)			
	Arctopsyche grandis			0.032 (T4A)			
Malathion (57% concentrate emulsified in xylene)	*Acroneuria pacifica*	BSA	–	0.0072 (T4A)	a c d e l m	Test water was obtained from a mountain stream.	Gaufin, et al (1961)
	Hydropsyche californica			0.0225 (T4A)			
	Arctopsyche grandis			0.032 (T4A)			
	Claassenia sabulosa			0.056 (T4A)			
	Pteronarcys californica			0.1 (T4A)			
Malathion	*Oncorhynchus tshawytscha*	BSA	–	23 (T4A)	a c d e	Chemical dissolved in acetone. TL_m expressed in ppb.	Katz (1961)
	Gasterosteus aculeatus			94 (T4A)			
Malathion (81 percent EC)	*Gambusia affinis*	FL	Ponds—Bakersfield, Cal.	(O)	a c	At 0.5 lb/acre, 48 percent mortality occurred in 24 hours. At 2.0 lb/acre, 54 percent mortality occurred in 24 hours. The experiments were conducted in cages placed in the ponds.	Mulla and Isaak (1961)
Malathion (0,0-dimethyl dithiophosphate of diethyl mercaptosuccinate)	*Richardsonius balteatus hydroflox*	BSA	–	13.6 (T1A) 11.4 (T2A) 8.9 (T4A)	a c d e f	Results given were in soft water. Results in hard water were as follows: 11.7 (T1A), 9.6 (T2A), and 9.6 (T4A).	Webb (1961)

Malathion	Killifish *Cyprinodon* *Fundulus* *Gambusia* *Mollienesia*	F	–	0.2-0.75 lb/acre (O)	–	Extensive mortality.	Spiller (1961)
	Salmon (fingerlings)	BSA	–	0.1 (K 100%)		Decidedly toxic.	
	Carp			3.0 (K 60%)		Killed 60% of test fish.	
	Bluegill (fingerlings)			5.0 (K 100%)		Lethal dose.	
	Goldfish Rainbow trout Sunfish Yellow perch Fathead minnow			25 (O)		LD_{50} in 24 hours.	
Malathion	*Micropterus salmoides*	BSA	–	0.5 (O)	–	The degree of reaction to the cholinesterase-inhibiting insecticides is not only a function of time and concentration, but also of chemical and biological species. This paper reports many analyses of brain cholinesterase activity which is expressed as percentage of normal. The data are reported as LT_{50} which was the time required for 0.5 ppm of the chemical to kill 50 percent of the fish. For bass the LT_{50} was 2 hr and 40 min and for fatheads 72 hr.	Weiss (1961)
	Pimephales promelas			0.5 (O)			
Malathion (granular)	*Stizostedion vitreum*	BSA	–	1.84 (O)	a e	Five percent of the fish survived 24 hours at the indicated concentration. Emulsions were more toxic than granular formulations of the chemical.	Hilsenhoff (1962)
Malathion	*Salmo gairdnerii* (one wk old sac fry)	BSA	–	1.0 (K 26%) 10.0 (K 100%)	a e	Results are averages of triplicate tests. Toxicity is reported as percent mortality (K %).	Lewellen and Wilder (1962)
	(one mo old feeding fry)	BSA	–	1.0 (K 100%) 10.0 (K 100%)			
Malathion, emulsible concentrate (20 percent)	*Lepomis macrochirus*	BSA	–	Large 1.2 (T4A) Small 0.55 (T4A)	a c d e	Soft water primarily was the test medium. TL_m's reported for 24, 48, and 96 hr. Acetone or alcohol used as solvent or carrier in most cases.	Pickering, et al (1962)
	Green sunfish			0.60 (T4A)			
	Largemouth bass			0.25 (T4A)			
Malathion, (tech, 100 percent)	*Pimephales promelas*	BSA	–	23 (T4A)	a c d e	Comment same as above.	Pickering, et al (1962)
	Lepomis macrochirus			0.090 (T4A)			
	Lebistes reticulatus			0.84 (T4A)			
Malathion, emulsible concentrate (57 percent)	*Pimephales promelas*	BSA	–	25 (T4A)	a c d e	Soft water primarily was the test medium. TL_m's reported for 24, 48, and 96 hr. Acetone or alcohol used as solvent or carrier in most cases.	Pickering, et al (1962)
	Lepomis macrochirus			0.088 (T4A)			
	Carassius auratus			0.79 (T4A)			

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Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Malathion	*Lepomis macrochirus*	BSA	—	0.28 (T1A) 0.22 (T1A) 0.135 (T1A) 0.124 (T1A) 0.07 (T1A)	a	The experiment was conducted at 45 F. The experiment was conducted at 55 F. The experiment was conducted at 65 F. The experiment was conducted at 75 F. The experiment was conducted at 85 F.	Cope (1963)
Malathion	*Culex pipiens quadrimaculatus*	BSA	—	(O)	c	Tests were conducted in tap water and artificially polluted tap water. The values reported are the concentration range for an LC_{90}, 0.045 to 0.120 ppm in polluted water and 0.100 to 0.240 in tap water.	Lewallen and Wilder (1963)
Malathion (tech)	*Salmo gairdneri*	BSA	—	100 (T1A)	a	The experiment was conducted at 55 F. Fish were 2-3 in. long.	Cope (1963)
	Redear			170 (T1A) 100 (T2A) 60 (T4A)		The experiment was conducted at 75 F. Fish weighed 3 g.	
	Lepomis macrochirus			45 (T1A) 35 (T2A)		The experiment was conducted at 75 F. Fish weighed 0.4 g.	
				120 (T1A)		The experiment was conducted at 75 F. Fish weighed 0.6 g.	
Malathion	*Daphnia magna*	BSA	—	0.002 (T2A) 0.010 (K)	a c e	Acetone was used as a solvent for the Malathion. Each test solution contained 0.1% acetone.	Gillespie (1964)
Malathion	*Gammarus lacustris*	BSA	—	0.00162 (T4A)	a e	Emulsible concentrates were prepared from technical grade insecticides with acetone as the solvent. Symptoms prior to death were observed and recorded on graphs.	Nebeker and Gaufin (1964)
Malathion (tech, 95 percent active in acetone)	*Pteronarcys californica* (naiad)	BSA	—	0.0500 (T4A)	c d e f	*A. pacifica* was much more sensitive to chlorinated hydrocarbons and to organic phosphate insecticides than *P. californica*.	Jensen and Gaufin (1964)
	Acroneuria pacifica (naiad)			0.0070 (T4A)			
Malathion	Bluegill	BSA	—	0.090 (T4A)	a	Assays were conducted in soft water at 25 C. Decrease in brain cholinesterase was measured in fish exposed to the toxicant.	Weiss (1964)
Malathion	*Carassius auratus*	BSCH	—	1.0 (O)*	a c d e	Toxicity was determined by measuring acetylcholinesterase activity in the brains of fish. Concentrations are given in ppb as either response or not response in 15 or 30 days.	Weiss and Gakstatter (1964)
	Lepomis macrochirus			1.0 (O)*			
	Notemigonus crysoleucus			1.0 (O)* *response, 15 days			
Malathion	Rainbow trout	BSA	—	77 (T4A) 68 (T4A) 110 (T4A)	a	These experiments were performed to show the effect of temperature on the toxicity. For the toxicant concentrations listed, the temperatures were respectively 45, 55, and 65 F. The fish all were approximately one g in weight. Toxicant concentrations for one and 2-day times were also listed.	Cope (1965)

Malathion	*Acroneuria pacifica*	BSA	–	0.007 (T4A)	a c	Additional TL_m data are given.	Gaufin, et al (1965)
	Ephemerella grandis			0.10 (T4A)			
	Gammarus lacustris			0.0016 (T4A)			
	Pteronarcys californica			0.05 (T4A)			
Malathion	*Pteronarcys californica*	BSA	–	0.05 (T4A)	a	Unspecified chemical characteristics of assay water were determined by standard methods. General comments were made concerning "standardized" conditions, use of "soft" water, and use of emulsifying agents. Additional data are presented.	Gaufin, et al (1965)
	Acroneuria pacifica			0.007 (T4A)			
	Ephemerella grandis			0.100 (T4A)			
	Arctopsyche grandis			0.02 (T4A)			
	Hydropsyche californica			0.007 (T4A)			
	Daphnia magna			0.009 (T 50 hr A)			
	Gammarus lacustris			0.002 (T4A)			
	Fathead minnow			12.5 (T4A)			
Malathion, 3,2,dibrom	*Lepomis gibbosus*	BSA	–	0.075 (T2A)	a c	This paper contained both bioassay and field studies. The tests revealed that a mixture of 3 parts of actual Dibrom and 2 parts of actual Malathion (by weight) applied at 0.10 ppm was more toxic to bluegills and pumpkinseeds than to largemouth bass.	Hoff and Westman (1965)
	Lepomis macrochirus			0.075 (T2A)			
	Enneacanthus gloriosus			0.075 (T2A)			
	Esox niger			0.075 (T2A)			
	Enneacanthus chaetodon			0.075 (T2A)			
	Lepomis microlophus			0.08 (T2A)			
	Salmo trutta			0.08 (T2A)			
	Salmo gairdnerii			0.08 (T2A)			
	Lepomis auritus			0.085 (T2A)			
	Perca flavescens			0.09 (T2A)			
	Micropterus salmoides			0.10 (T2A)			
	Fundulus diaphanus			0.10 (T2A)			
	Catostomus commersoni			1.5 (T2A)			
	Notemigonus crysoleucas			3.2 (T2A)			
	Erimyzon oblongus			4.2 (T2A)			

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Malathion, 3,2,dibrom	Yellow perch Pumpkinseed Bluegill Golden shiner Brown bullhead Chain pickerel Largemouth bass Black crappie	FL	Silver Lake, Conn.	(O)	a c e	At 0.10 ppm sunfish kill was extremely heavy, the fish were still dying after 7 days. Many young of the year fish of all species were killed.	Hoff and Westman (1965)
	Pumpkinseed Yellow perch White perch Largemouth bass Brown bullhead		Pooley Lake, Conn.	(O)		Kill of pumpkinseeds was slight. A few young of the year bass were killed at a concentration of 0.10 ppm.	
	Rainbow trout Pumpkinseed Bluegill Largemouth bass		A lake in N.J.	(O)		At a concentration of 0.10 the kill of bluegills was very heavy by the second day after treatment. Seining before treatment indicated that about 70 percent of the bluegills were killed, largemouth bass were still common.	
	White perch Bluegill Largemouth bass Yellow perch Black crappie Channel catfish Gizzard shad Carp		Greenwich Lake, N.J.	(O)		The first application at 0.10 percent concentration appeared to kill about 80 percent of the white perch population and about 50 percent of bluegills.	
	Largemouth bass Black crappie Chain pickerel Bluegill Yellow perch Golden shiner Pumpkinseed Banded sunfish Brown bullhead		2 lakes in Mass.	(O)		The results were quite similar to those noted above at a concentration of 0.10. Largemouth bass were abundant and apparently minimally affected. Bioassay results are also presented.	
Malathion, (95% active in acetone)	*Hexagenia*	BSA	–	0.63 (T1A)	a e	Dissolved oxygen was measured before and after assay. Assays were conducted in Mississippi River water.	Carlson (1966)
	Hydropsyche (larva)			0.102 (T1A)			
	Bluegill			0.14 (T1A)			
Malathion	*Salmo gairdnerii*	BSA	–	0.079 (T2A)	a	This paper reports acute toxicity of a number of compounds, and discusses subacute mortality as well. Effects on reproduction and behavior are also discussed. Data presented as EC_{50}.	Cope (1966)
	Lepomis macrochirus			0.086 (T2A)			
	Ictalurus punctatus			8.900 (T2A)			
	Pteronarcys californica			0.020 (T2A)			
	Baetis sp			0.006 (T2A)			

	Daphnia pulex			0.002 (T2A)			
	Simocephalus serrulatus			0.003 (T2A)			
Malathion	*Lepomis gibbosus* *Ictalurus melas* *Pseudopleuronectes americanus* *Myxocephalus scorpius*		–	161.0 ± 19.5 (O) 11.6 ± 2.0 (O) 16.9 ± 3.8 (O) 6.1 ± 0.8 (O)	–	This paper is a study of the amounts of organic thiophosphate and their oxygen analogues which accumulate in liver slices in an *in vitro* study of insecticides. The numbers given are for mμm of chemical (in the case of Parathion, Malathion, and Guthion – the oxygen analogue) accumulated in 100 mg (dry weight) of liver in 30 minutes.	Murphy (1966)
Malathion	*Lepomis gibbosus*	BSA	–	2/4 (O)	–	The figures given are for mortality in 2 hours when the amount of chemical was 100.0 mg/kg, given by injection.	Murphy (1966)
Malathion	Sewage organisms	BOD	–	(O)	–	Shock loadings of the chemical as high as 100.0 mg/l were assimilated by microbial systems of 2000.0 mg/l with no observable toxic effect. Organophosphate insecticides in low concentration stimulated microbial respiration; however, greater concentrations inhibited the system and eventually destroyed the organisms. The amount of organophosphate insecticide required to inhibit the respiration of freshwater microorganisms was shown to be function of the amount of organisms present and not the volume of water in which the organisms are dispersed.	Randall (1966)
Malathion	*Daphnia magna*	BSA	–	0.0009 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
Malathion	*Daphnia carinata*	BSA	–	0.0002 (SB)	–	Comment same as above.	Sanders and Cope (1966)
Malathion	*Simocephalus serrulatus* *Daphnia pulex*	BSA	–	0.0035 (SB)	–	Comment same as above, except that time for immobilization was 48 hr and data were cited for 60 F.	Sanders and Cope (1966)
Malathion	*Tubifex* spp *Limnodrilus* spp	BSA	–	16-7 (L4A)	a c e	Toxicity is reported as the mean lethal dose (LD_{50}) for 24, 48, and 96 hours.	Whitten and Goodnight (1966)
Malathion	*Leiostomus xanthurus*	BCFCH	–	0.01 (SB 182)	a	A concentration of 0.050 ppm killed juvenile spat in 14 days.	Butler and Johnson (1967)
Malathion	*Leiostomus xanthurus* *Cyprinodon variegatus*	BCFCH	–	0.1 (O) 0.1 (O)	a	At a concentration of 0.1 ppm, the following percent acetylcholinesterase activity as compared to controls was found: *L. xanthurus* –76 *C. variegatus* –39	Butler and Johnson (1967)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Malathion	Stream insects: Ephemeroptera Odonata Plecoptera Trichoptera Diptera Coleoptera Neuroptera	FR	Maine	(O)	–	At an application rate of 1.2 pounds per acre, percent reduction of the number of major insects is given with 0 to 66% reduction estimated. Population modifications were not severe and were considered transitory. Malathion is a safer chemical than DDT because it is not known to leave persistent residues. Thirty genera of aquatic insects were studied.	Dimond (1967)
Malathion	*Mercenaria mercenaria* American eel Mummichog Striped mullet Northern puffer Atlantic silverside Grass shrimp Sand shrimp Hermit crab	BSA	–	(O)	a c e	A 37,000 ppb exposure for 4 days caused no mortality of quahog clams. The LC_{50} values (96 hour) for this chemical extended from 8 to 3,250 ppb for fish, and from 33 to 83 ppb for crustaceans.	Eisler and Weinstein (1967)
Malathion	Atlantic salmon Brook trout	FR	New Brunswick	(O)	–	Spraying with this chemical at 1/8 lb per acre was no more harmful than the application of DDT at 1/4 lb per acre.	Kerswill and Edwards (1967)
Malathion	*Pimephales promelas*	BSA & CH	–	9.0 (T4A)	a c d e f	The fish could tolerate 1/45 this amount of malathion for a 10-month test.	Mount and Stephan (1967)
Malathion	*Pimephales promelas*	BCFCH	–	0.2-0.58 (O)	a c d e q	Carbon-filtered tap water was used as diluent. Malathion at indicated range of concentrations did not affect growth and reproduction, although 20% of fish died at the 0.58 ppm concentration during 7 weeks of exposure.	Mount and Stephan (1967)
Malathion	*Puntius puckelli*	BSA	–	3.7 (T4A)	a c d e l m	Tap water was used as diluent. Toxicity data are given as TL_m's in ppm for 24, 48, 96 hr. The pH of the water averaged 8.3. The study was conducted in India.	Rao, et al (1967)
Malathion	*Pteronarcys californica* (naiads)	BSA	–	0.01 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Malathion	*Pteronarcys californica* (naiads)	BSA	–	0.010 (T4A)	a c d e f	Comment same as above.	Sanders and Cope (1968)
	Pteronarcella badia (naiads)			0.0011 (T4A)			
	Claasenia sabulosa (naiads)			0.0028 (T4A)			

Malathion	Trout	BSA	–	0.0050 (T1A) 0.0046 (T2A) 0.0028 (T4A) 0.0023 (T5A)	a c d e f i	The objects of this investigation were the recovery of organic micropollutants from subsurface and surface Missouri waters, characterization and identification of these substances, and evaluation of their toxic effects, both acute and long-term, in order to develop methods for their destruction or removal.	Smith and Grigoropoulos (1968)
	Red shiner			0.040 (T1A) 0.036 (T2A) 0.025 (T4A) 0.023 (T5A)			
Malathion	*Lepomis gibbosus* *Ictalurus melas* *Micropterus dolomieui* *Myxocephalus scorpius* *Pseudopleuronectes americanus*	BSA	–	(O)	a p	The chemicals were poor inhibitors of brain cholinesterases *in vitro*; their oxygen analogs were potent inhibitors.	Murphy, et al (1968)
Manzate	Channel catfish (fingerlings)	BSA	–	2.7 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
2-mercaptobenzothiazole	*Daphnia magna*	BSA	–	2 (K2)	a	An attempt was made to correlate the biological action with the chemical reactivity of selected chemical substances. Results indicated a considerable correlation between the aquarium fish toxicity and anti-autocatalytic potency of the chemicals,in marked contrast to their toxicity on systemic administration.	Sollman (1949)
Merthiolate	*Salmo gairdnerii*	BSA	–	21.2 (T2A)	a f	Variance and the 95-percent confidence interval (C.I.) were also determined.	Willford (1966)
	Salmo trutta			54.0 (T2A)			
	Salvelinus fontinalis			74.5 (T2A)			
	Salvelinus namaycush			2.13 (T2A)			
	Ictalurus punctatus			5.65 (T2A)			
	Lepomis macrochirus			64.5 (T2A)			
Metacide (dialkyl nitroaryl thiophosphate, 33.4 percent)	Lymnaeid snails	BSA	–	(O)	–	Each test container, 500-ml beaker, was filled with ditch water. 100% mortality occurred at 1:300,000 and greater.	Batte, et al (1951)
Meta-Systox R	Oyster	BCF	–	(O)	a	No effect on exposure to the chemical at 1.0 ppm.	Butler (1965)
Metasystox	*Cyprinus carpio*	BSA	–	9.0 (T2A)	a c d e f p	The test animals were conditioned for 48 hours prior to use.	Sreenivasan and Swaminathan (1967)
	C. carpio			20.0-25.0 (T2A) 12.0-12.5 (T2A)			
	Tilapia mossambica			17.0 (T2A)			
	Cirrhina mrigala			16.0 (T2A)			
	Labeo fimbriatus						

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Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Methoxychlor	Fathead minnow	BSA	–	0.035 (T4A)	a	It was the authors opinion that pH, alkalinity and hardness, within the usual range in natural waters, had little effect on the toxic effect of the compounds studied. The values given are from Henderson, Pickering, and Tarzwell, "The Relative Toxicity of Ten Chlorinated Hydrocarbon Insecticides to Four Species of Fish". It is interesting that the different tables from the above book (as reported in this paper) report widely different values for the same compounds. This experiment was performed in hard water.	Tarzwell (1959)
Methoxychlor	Fathead minnow	BSA	–	0.064 (T4A)	a	Comment same as above except that experiment was conducted in soft water.	Tarzwell (1959)
	Bluegill			0.062 (T4A)			
	Goldfish			0.056 (T4A)			
	Guppy			0.120 (T4A)			
Methoxychlor	*Daphnia magna*	BSA	–	0.0036 (O)	a	The indicated concentration immobilized *Daphnia* in 50 hours.	Anderson (1960)
Methoxychlor	*Pimephales promelas*	BSA	–	0.06 (T4A)	a d e f	Concentrations were based on percent active ingredient.	Henderson, et al (1959)
	Lepomis macrochirus			0.06 (T4A)			
	Carassius auratus			0.06 (T4A)			
	Lebistes reticulatus			0.12 (T4A)			
Methoxychlor (100%)	*Pimephales promelas*	BSA	–	0.064 (T4A)	a b e c d f	Dilution water was usually soft although some studies were conducted with hard water.	Henderson, et al (1959)
	Lepomis macrochirus			0.062 (T4A)			
	Carassius auratus			0.056 (T4A)			
	Lebistes reticulatus			0.120 (T4A)			
Methoxychlor	*Pimephales promelas*	BSA	–	0.064 (T4A)	a	Bioassay investigations of the new insecticides indicate that in general the organic phosphorus compounds are not as toxic to fish as are the chlorinated hydrocarbons. The toxicity of most of these materials was not significantly influenced by water quality. Therefore it is to be expected that the toxicity of these materials will not differ significantly in different streams.	Tarzwell (1959)
	Lepomis macrochirus			0.062 (T4A)			
Methoxychlor	*Oncorhynchus kisutch*	BSA	–	66.2 (T4A)	a c d e	Chemical dissolved in acetone. TL_m expressed in ppb.	Katz (1961)
	Oncorhynchus tshawytscha			27.9 (T4A)			
	Salmo geirdnerii			62.6 (T4A)			
	Gasterosteus aculeatus			86.4 (T4A)			

Methoxychlor (EC 2)	*Gambusia affinis*	FL	Cal.	2.0 (O)	a c	Mixed populations of the indicated test species contained in cages were exposed to various insecticidal chemicals applied as dilute sprays to ponds 1/16 acre in size. The indicated toxicant concentration is in lb/acre, and resulted in a 6 percent mortality for these fish.	Mulla (1963)
Methoxychlor (tech)	*Salmo gairdnerii*	BSA	–	20 (T1A)	a	The experiment was conducted at 55 F. Fish weighed 0.7 g.	Cope (1963)
Methoxychlor	*Gambusia affinis*	BSA	–	0.6 (L1)* 0.9 (L1)** * Resistant fish **Nonresistant fish	a	This paper deals with the resistance of mosquito fish to chlorinated hydrocarbon compounds. Resistant fish were not always less sensitive to these chemicals.	Boyd and Ferguson (1964)
Methoxychlor	Bluegill	BSA	–	0.062 (T4A)	a	Assays were conducted in soft water at 25 C. Decrease in brain cholinesterase was measured in fish exposed to the toxicant.	Weiss (1964)
Methoxychlor	*Pteronarcys* sp (nymphs)	BSA	–	0.0014 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Methoxychlor	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	–	0.04 (O)	a	Stones heavily populated with wild larvae were placed in troughs of running water containing the toxicant. When the larvae became detached from the rocks and floated away, they were assumed to have undergone lethal intoxication. The larvae were exposed to the toxicant for 5 minutes, then in clean water for 24 hours. At that time the number detached amounted to 33 percent.	Jamnback and Frempong-Boadu (1966)
Methoxychlor	*Daphnia magna*	BSA	–	0.0037 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
Methoxychlor	*Simocephalus serrulatus* *Daphnia pulex*	BSA	–	0.005 (SB) 0.00078 (SB)	–	Comment same as above except that time for immobilization was 48 hr and data were cited for 60 F.	Sanders and Cope (1966)
Methoxychlor	*Mya arenaria* *Crassostrea virginica* *Corbicula manillensis* *Mercenaria mercenaria* *Rangia cuneata*	BCFCH	–	(O)	–	Results are recorded as a range of uptake of the chemical by 5 species of aquatic mollusks. An uptake or concentration of 300-1500 ppb resulted.	Butler (1967)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Methoxychlor	*Mercenaria mercenaria* American eel Mummichog Striped mullet Northern puffer Atlantic silverside Grass shrimp Sand shrimp Hermit crab	BSA	–	(O)	a c e	At 1,100 ppb exposure for 4 days caused no mortality of the quahog clam. Although this organism was quite resistant to this chemical, other organisms were susceptible. A 4 day TL_m of 12 to 150 ppb was found for such fish as the American eel, mummichog, striped mullet, northern puffer, Atlantic silverside; and between 4 and 12 ppb for crustaceans (including grass shrimp, sand shrimp, and hermit crab).	Eisler and Weinstein (1967)
Methoxychlor	*Lampsilis siliguoidea* *L. vertricosa* *Anodonta grandis*	FR	Red Cedar River, Mich.	(O)	–	The mussels listed were analyzed for the toxicant and its metabolites. Mussels may be used as detectors for this toxicant because they tend to concentrate the chemical in much higher concentrations than it is ever found in the water. The amount of chemical applied as a spray was not specified.	Bedford, et al (1968)
Methoxychlor	*Pteronarcys californica* (naiads)	BSA	–	0.0014 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Methylene blue	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
Methylene blue	*Micropetrus salmoides* (fry)	BSA	–	5.0 (SB3)	a c d e f p	At least 90 percent of the fry survived for a period of 72 hours at the concentration listed.	Jones (1965)
	Ictalurus punctatus (fry)			5.0 (SB3)			
	Lepomis macrochirus (fry)			5.0 (SB3)			
Methylene blue	*Salmo gairdneri*	BSA	–	10.0 (T2A)	a f	Variance and the 95-percent confidence interval (C.I.) were also determined.	Willford (1966)
	Salmo trutta			32.8 (T2A)			
	Salvelinus fontinalis			22.9 (T2A)			
	Salvelinus namaycush			34.0 (T2A)			
	Ictalurus punctatus			104 (T2A)			
	Lepomis macrochirus			33.0 (T2A)			

Methyl carbo-phenothion	*Chaoborus astictopus*	BSA	–	0.0064 (T1A)	a	Toxicity value given is for the fourth instar.	Hazeltine (1963)
Methyl green	*Microcystis aeruginosa*	L	–	100 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
Methyl parathion	*Pimephales promelas*	BSA	–	10.4 (T4A)	a c d e f	Tests were performed in both hard and soft water. Additional tolerance limit values are given.	Henderson and Pickering (1958)
Methyl parathion	Fathead minnow	BSA	–	7.5 (T4A)	a	It was the authors opinion that pH, alkalinity and hardness, within the usual range in natural waters, had little effect on the toxic effect of the compounds studied. The values given are from Henderson, Pickering, and Tarzwell, "The Relative Toxicity of Ten Chlorinated Hydrocarbon Insecticides to Four Species of Fish". It is interesting that the different tables from the above book (as reported in this paper) report widely different values for the same compounds. This experiment was performed in hard water.	Tarzwell (1959)
Methyl parathion	*Pimephales promelas*	BSA	–	8.3 (T4A)	a d e f	Concentrations were based on percent active ingredient.	Henderson, et al (1960)
Methyl parathion	*Pimephales promelas*	BSA	–	8.3 (T4A)	a	Bioassay investigations of the new insecticides indicate that in general the organic phosphorus compounds are not as toxic to fish as are the chlorinated hydrocarbons. The toxicity of most of these materials was not significantly influenced by water quality. Therefore it is to be expected that the toxicity of these materials will not differ significantly in different streams.	Tarzwell (1959)
Methyl parathion (tech, 80 percent)	*Pimephales promelas* *Lepomis macrochirus* *Carassius auratus* *Lebistes reticulatus*	BSA	–	9.5 (T4A) 2.4 (T4A) 12.0 (T4A) 9.8 (T4A)	a c d e	Soft water primarily was the test medium. TL_m's reported for 24, 48, and 96 hr. Acetone or alcohol used as solvent or carrier in most cases.	Pickering, et al (1962)
Methyl parathion (tech)	*Lepomis macrochirus*	BSA	–	8,500 (T1A)	a	The experiment was conducted at 75 F. Fish weighed 0.6 g.	Cope (1963)
Methyl parathion	*Chaoborus astictopus*	FL	Clear Lake, other ponds & lakes, Cal.	(O)	–	Methyl parathion applied to 2.3 ppb and 3.3 ppb at intervals within 2 months was sufficient to control gnats in clear lake.	Hazeltine (1963)
Methyl parathion	*Chaoborus astictopus* *Lepomis macrochirus*	BSA	–	(O) 0.115 (T10A)	– a	Tests were conducted on bluegill, sunfish, *C. astictopus* first instar larvae, and fourth instar larvae, results on larvae were as follows: Fourth instar 0.0058 (T1A) First instar 0.0012 (T1A)	Hazeltine (1963)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Methyl parathion (EC7.5)	*Gambusia affinis* *Bufo boreas* *Scophiopus hammondi*	FL	Ponds in Ill.	(O) (O) (O)	–	When applied at 0.8 pound per acre active ingredient, 10 percent fish mortality occurred in 1 day. No toad mortality occurred at 0.4 pound per acre in 1 day.	Mulla, et al (1963)
Methyl parathion (tech grade)	*Procamberus clarki*	BSA	–	0.04 (T3A)	a c d o	There was no detectable difference in toxicity to male or female crawfish.	Muncy and Oliver (1963)
Methyl parathion	Bluegill	BSA	–	1.9 (T4A)	a	Assays were conducted in soft water at 25 C. Decrease in brain cholinesterase was measured in fish exposed to the toxicant.	Weiss (1964)
Methyl parathion	*Carassius auratus* *Lepomis macrochirus* *Notemigonus crysoleucus*	BSCH	–	10 (O)* 1.0 (O)* 10.0 (O)** 1.07 (O)** 1.0 (R-30 da) 1.0 (O)** * no response, 15 days **response, 15 days	a c d e	Toxicity was determined by measuring acetylcholinesterase activity in the brains of fish. Concentrations are given in ppb as either response or not response in 15 or 30 days.	Weiss and Gakstatter (1964)
Methyl parathion	Phytoplankton Zooplankton Chironomids Oligochaetes Fish	FL	Clear Lake, Cal.	–	a	The purpose of this field study was to determine the effect of methyl parathion at 3 ppb or .003 ppm (used to control gnats *Chaoborus astictopus*) on other organisms in the treated area. It appears that the treatments of Clear Lake had minimal influence upon the biota of the lake with the exception of the Clear Lake gnat larvae and to a lesser degree, perhaps, species of the zooplankton. This is a very general paper and there are no numerical data given.	Cook and Conners (1963)
Methyl parathion	*Procambarus clarkii* (juvenile)	BSA	–	<1.0 (T5A)	a c d o	The pesticides studied in this report are widely used in rice culture in Louisiana and are toxic to crawfish.	Hendrick and Everett (1965)
Methyl parathion	*Gambusia affinis*	BSA	–	(O)	a	The effect of combinations of pesticides was studied. In general, the results reflected the extreme levels of Endrin and Toxaphene resistance in the resistant population. The results failed to indicate additive effects wherein the combination mortality exceeded the sum of the mortalities produced by the individual insecticides.	Ferguson and Bingham (1966)
Methyl parathion	*Procambarus clarkii*	FO	Crowley, La.	(O)	c d e p	Experiments were conducted in a flooded rice field. Area was divided into 4 blocks with a fence, restricting crawfish to desired areas. The rearing of crawfish in rice fields is of considerable commercial importance in Louisiana. No untoward effect on the crawfish occurred. The chemical was applied at the rate of 25 lb/acre.	Hendrick, et al (1966)

Methyl parathion	*Puntius puckelli*	BSA	—	2.1 (T4A)	a c d e l m	Tap water was used as diluent. Toxicity data are given as TL_m's in ppm for 24, 48, 96 hr. The pH of the water averaged 8.3. The study was conducted in India.	Rao, et al (1967)
Methyl trithion (50 percent EC)	*Gambusia affinis*	FL	Ponds—Bakersfield, Cal.	(O)	a c	At 0.5 lb/acre, 14 percent mortality occurred in 24 hours. At 2.0 lb/acre, 76 percent mortality occurred in 24 hours. The experiments were conducted in cages placed in the ponds.	Mulla and Isaak (1961)
Methyl zimate	*Pimephales promelas*	BSA	—	0.25 (T4A)	a c d e f	The toxicity of this substance was influenced by the quality of the water (pH, hardness, alkalinity). The chemical was more toxic in soft water.	Pickering and Henderson (1966)
MGK's Evergreen	*Salmo gairdneri*	BSA	—	800 (T1A)	a	The experiment was conducted at 55 F. Fish weighed 0.4 g.	Cope (1963)
MGK's 6103	*Salmo gairdneri*	BSA	—	150 (T1A)	a	The experiment was conducted at 55 F. Fish weighed 0.5 g.	Cope (1963)
MGK's 6243	*Salmo gairdneri*	BSA	—	750 (T1A)	a	The experiment was conducted at 55 F. Fish weighed 0.8 g.	Cope (1963)
Ortho-MH 30	Channel catfish (fingerlings)	BSA	—	>2.4 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Mirex	*Lepomis macrochirus* *Carassius auratus* *Salmo clarki*	FLCH	—	5.0 (SB) 0.1-1.0 (SB 224) 75.0 (SB 14)	—	No histological lesions or effects on hematocrit or serum protein were observed in the bluegill. Lesions on and fusion of gills occurred with the trout at the indicated concentration. Gill changes and accumulation in goldfish were found in concentrations of 2.0-1372 ppm in skin, muscle, liver, and gut.	Van Valin, et al (1968)
Mobam (r-benzothienyl-N-methyl carbamate)	*Australorbis glabratus*	BSA and FL	Puerto Rico	(O)	c	Seven of the tested compounds failed to meet acceptability criteria — that is, complete kill after 6-hr exposure to 10 ppm. They were not used in field tests. Field tests showed WL 8008 to be highly effective.	Seiffer and Schoof (1967)
Molinate (Ordram)	*Daphnia magna* Rainbow trout Bluegill	BSA	—	0.70 (.46-1.05 (O) 0.29 (O) 0.48 (O)	a c d i q	Toxicity, in terms of median immobilization concentration (IC_{50}), is presented for *Daphnia*; median lethal concentration (LC_{50}) values for rainbow trout and bluegill are reported.	Crosby and Tucker (1966)
Molinate (tech)	*Pteronarcys californica* (naiads)	BSA	—	.00034 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Molucid (isobutyl-triphenyl-methylamine	*Bulinus truncatus* *Biomorpholaria alexandrina* *Lymnaea caillaudi*	FO	Arabia	1.6-2.0 (O)	a b g	Tests were conducted in the Hod el Malaha canal which has a maximum discharge of 11,250 m^3/day. The molluscicide was dispersed by the injection method, with flow regulated by a tap, a concentration of 2 ppm being maintained during 6 hr of continuous application. The Meyling, Schutte & Pitchford method was used for determining the concentration of molluscicide in the canal. No live organisms were observed for 2, 3, and 4 months after treatment. Egg masses were apparently unaffected.	Dawood and Dazo (1966)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Monuron	*Oncorhynchus kisutch*	BSA and FL	—	115 (T1) 110 (T2)	a c d e	Concentrations were based on percent active ingredient. Treatment of ponds with 5 and 10 ppm Monuron apparently caused no mortality of frogs, tadpoles, or fishes.	Bond, et al (1960)
Monuron	*Protococcus* sp *Chlorella* sp *Dunaliella euchlora* *Phaeodactylum tricornutum* *Monochrysis lutheri*	L	—	0.02 (NG) 0.02 (NG) 0.02 (NG) 0.02 (NG) 0.02 (K)	a	This paper concerns the growth of pure cultures of marine plankton in the presence of toxicants. Results were expressed as the ratio of optical density of growth in the presence of toxicants to optical density in the basal medium with no added toxicants. NG = no growth, but the organisms were viable.	Ukeles (1962)
Monuron	*Crassostrea virginica* *Penaeus setiferus* *Mugil cephalus* Phytoplankton	BCFA & BSA	—	2.0 (0, 12%) 0.55 (O) 16.3 (T2A) 94% (O)	—	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster — 96-hr EC_{50} — Conc. which decreased shell growth. Shrimp — 48-hr EC_{50} — Conc. which killed or paralyzed 50% of test animals. Fish — 48-hr EC_{50} — Conc. which killed 50%. Phytoplankton — Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
Monuron (25 percent pellet)	*Lepomis macrochirus* *Lepomis macrochirus*	BSA	—	40.0 (T4A) 47.0 (T4A)	—	Laboratory bioassays indicated that toxicity of the different formulations evaluated in this varied greatly with the fish used. Mortality data are expressed as EC_{10}, EC_{50}, etc.	Walker (1965)
Monuron (80 percent WP)	*Ictalurus nebulosis* *Lepomis macrochirus*	BSA	—	57.0 (T4A) 33.0 (T4A)	—	Comment same as above.	Walker (1965)
Monuron	*Daphnia magna*	BSA	—	106 (O)	a c d i q	Toxicity, in terms of median immobilization concentration (IC_{50}), is presented.	Crosby and Tucker (1966)
Monuron (CMV)	Salmon	BSA	—	110.3 (T2A)	—	Data are given as LC_{50}.	Bohmont (1967)
Monuron-borate (4-percent granular)	*Lepomis macrochirus*	BSA	—	26.0 (T4A)	—	Laboratory bioassays indicated that toxicity of the different formulations varied greatly with the fish used. Mortality data are expressed as EC_{10}, EC_{50}, etc.	Walker (1965)
Monuron-TCA (3 lb/gal)	*Lepomis macrochirus* *Micropterus salmoides*	BSA	—	1.5-1.8 (T4A) 2.7 (T4A)	—	Comment same as above.	Walker (1965)

Monuron-TCA (22 percent granular)	*Lepomis macrochirus*	BSA	–	4.8 (T4A)	–	Comment same as above.	Walker (1965)
Monuron-TCA (11 percent granular)	*Lepomis macrochirus*	BSA	–	3.8 (T4A)	–	Comment same as above.	Walker (1965)
Monuron-TCA (tech)	*Lepomis macrochirus*	BSA	–	4.5 to 5.0 (T4A)	–	Comment same as above.	Walker (1965)
	Lepomis microlophus			5.4 (T4A)			
	Micropterus salmoides			4.8 (T4A)			
	Pumpkinseed			3.3 (T4A)			
Monuron TCA	*Lepomis macrochirus* (eggs)	L	–	10 (NTE)	–	Fertilized fish eggs of indicated species were placed in 1 liter of test solution and allowed to hatch. Toxicity data are presented as concentration in ppm/number of days survival. Maximum length of test was 8 days. No food was added. Small bluegill were tested to find the highest concentration of chemical which did not cause death in 12 days (S).	Hiltibran (1967)
	L. cyanellus (eggs)			10/5 (O)			
	Micropterus dolomieui (eggs)			10/4 (O)			
	Erimyzon sucetta (eggs)			10 (NTE)			
	L. macrochirus (fry)			20 (S)			
MS-222	*Salmo gairdnerii*	BSA	–	39.0 (T1A) 39.0 (T2A)	a e f	Large specimens of given species were usually more resistant to MS-222 than small ones. Trout were more tolerant at lower temperatures. A safety index of concentration is suggested.	Marking (1967)
	Salmo trutta			38.5 (T1A) 37.5 (T2A)			
	Salvelinus fontinalis			50.7 (T1A) 50.0 (T2A)			
	Salvelinus namaycush			33.8 (T1A) 33.0 (T2A)			
	Esox lucius			56.0 (T1A) 52.0 (T2A)			
	Lepomis macrochirus			45.7 (T1A) 45.7 (T2A)			
	Micropterus salmoides			42.0 (T1A) 42.0 (T2A)			
	Stizostedion vitreum			49.0 (T1A) 48.5 (T2A)			

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
MS-222	*Ictalurus punctatus*	BSA	–	12C 58.0 (T1A) 55.0 (T2A) 51.1 (T4A) 17C 60.5 (T1A) 60.0 (T2A) 60.0 (T4A) 22C 59.8 (T1A) 58.8 (T2A) 58.8 (T4A)	a c d e f	Anesthesia was induced within 2 minutes by concentrations of this chemical of 20 to 40 ppm. Concentrations of 20 to 40 ppm maintained sedation for 6 hours. Safety indices were determined for the anesthesia of channel catfish with MS-222. The toxicity of the chemical is greatly influenced by the size of the fish and also by temperature. TL_m's are recorded at 12, 17, and 22 degrees centigrade. It was found that catfish are relatively more resistant when the anesthetic is dissolved in soft water.	Schoettger, et al (1967)
Tricaine methane-sulfonate (MS-222)	*Salmo gairdnerii* *Salmo trutta* *Salvelinus fontinalis* *Salvelinus namaycush*	BSA	–	100 (SB) 80 (SB) 120 (SB) 135 (SB)	a c f	In this assay the chemical was tested for its efficacy as an anesthetic for the given fish at varied temperatures. Concentrations of 80-135 ppm of the chemical anesthetized all of these fish within 3 min at 7 to 17 C. 50 to 60 ppm induced a moderate rate of anesthesia which could be maintained for approximately 30 minutes. At 15 to 30 ppm, sedation was produced within 15 minutes and maintained for 5 to 6 hours. Lake trout required larger doses than the other salmonids for complete anesthesia. There was no relation between size of fish and efficacy of MS-222.	Schoettger and Julin (1967)
MS-222 (tricaine methane-sulfonate)	Rainbow trout	BSA	–	(O)	–	MS-222 can be detected in fish tissues by a modified Bratton-Marshall method. Interfering substances were more prevalent in liver and kidney than in blood and muscle. The recovery of spiked samples ranged from 89 to 112 percent. The method was more accurate for measuring MS-222 in blood and muscle than in kidney and liver.	Walker and Schoettger (1967)
MS-222 (tricaine methane-sulfonate)	Rainbow trout Brown trout Brook trout Lake trout	BSA	–	(O)	a f	The residues of MS-222 in selected tissues of fish at 7, 12, and 17 C and in waters of various hardnesses were measured by a modified Bratton-Marshall colorimetric method. The concentrations of drug in the blood, muscle, liver, and kidney of deeply anesthetized rainbow trout dissipated rapidly within 1 to 6 hours. The mean concentrations were 18 to 42 ppm in rainbow trout, 13 to 44 ppm in brown trout, 15 to 28 ppm in brook trout, and 15 to 32 ppm in lake trout.	Walker and Schoettger (1967)
M.S. 222 (tricaine methane-sulfonate)	*Salmo gairdneri*	BCFA	–	(O)	a	Fish anesthetized in 100 mg/l of M.S. 222 at 12 C excreted the drug in free and acetylated forms via the urine during a 24-hr recovery period in fresh water. Of the M.S. 222 excreted, 77-96% was acetylated. Blood and urine were cleared of the two fractions of M.S. 222 in 8 and 24 hr, respectively. Intraperitoneal injections of 10-100 mg/kg of M.S. 222 did not induce anesthesia; however, the 24-hr pattern of drug excretion was similar to that observed after anesthesia by immersion.	Hunn, et al (1968)

N-2404 EC4	*Gambusia affinis* Diving beetle (larvae) Chironomid (larvae) Dragonfly (naiads)	FL	Cal.	0.1 (K1) (O) (O) (O)	–	Toxicity value is in lb/acre. At the given rates, there was appreciable kill of diving beetle larvae and adults, chironamid larvae, and dragonfly naiads.	Mulla (1966)
N-2788 EC4	*Gambusia affinis*	FL	Cal.	0.1 (K1)	–	Toxicity value is in lb/acre.	Mulla (1966)
N-2790 EC4	*Gambusia affinis*	FL	Cal.	0.2 (K1)	–	Comment same as above.	Mulla (1966)
N-2790 EC4	*Gambusia affinis* *Rana catesbeiana*	FL	Cal.	1.0 (K1) (O)	–	Toxicity value is in lb/acre. No mortality in tadpoles of *R. catesbeiana* occurred during an exposure period of one week.	Mulla (1966)
Nabam	*Protococcus* sp *Chlorella* sp *Dunaliella euchlora* *Phaeodactylum trocornutum* *Monochrysis lutheri*	BSA	–	10.0 (K) 10.0 (K) 1.0 (K) 1.0 (NG) 10.0 (K) 1.0 (K)	a	This paper concerns the growth of pure cultures of marine plankton in the presence of toxicants. Results were expressed as the ratio of optical density of growth in the presence of toxicants to optical density in the basal medium with no added toxicants. NG = no growth, but the organisms were viable.	Ukeles (1962)
Naled (EC8)	*Gambusia affinis* *Rana catesbeiana*	FL	Ponds in Ill.	(O)	–	When applied at 2.0 pounds per acre active ingredient, 20 percent fish mortality occurred in 1 day. No bullfrog mortality occurred at 0.5 pound per acre in 1 day.	Mulla (1963)
Naled	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	–	0.4 (O)	a	Stones heavily populated with wild larvae were placed in troughs of running water containing the toxicant. When the larvae became detached from the rocks and floated away, they were assumed to have undergone lethal intoxication. The larvae were exposed to the toxicant for 5 minutes, then in clean water for 24 hours. At that time the number detached amounted to 22 percent.	Jamnback and Frempong-Boadu (1966)
Naled	*Pteronarcys californica* (naiads)	BSA	–	0.008 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Neburon	*Protococcus* sp *Chlorella* sp *Duraliella euchlora* *Phaeodactylum tricornutum* *Monochrysis lutheri*	BSA	–	0.20 (NG) 0.20 (K) 0.20 (NG) 0.20 (NG) 0.004 (K)	a	This paper concerns the growth of pure cultures of marine plankton in the presence of toxicants. Results were expressed as the ratio of optical density of growth in the presence of toxicants to optical density in the basal medium with no added toxicants. NG = no growth, but the organisms were viable.	Ukeles (1962)
Neburon	*Leiostomus xanthurus* (juvenile)	BSA	–	0.032 (O)	a	Water temperature was 21 C. The figure reported is a 48-hr EC_{50}.	Butler (1965)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Neburon	*Crassostrea virginica*	BCFA & BSA	–	0.41 (O)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
	Penaeus setiferus			0.55 (O)			
	Leiostomus xanthurus			0.22 (T2CFA)			
	Phytoplankton			90% (O)			
Neburon, 4 percent granular	*Pimephales notatus*	BSA	–	0.6 (T4A)	–	Laboratory bioassays indicated that toxicity of the different formulations evaluated in this varied greatly with the fish used. Mortality data are expressed as EC_{10}, EC_{50}, etc.	Walker (1965)
	Notropis umbratilis			0.9 (T4A)			
	Lepomis macrochirus			0.7 (T4A)			
	Lepomis microlophus			0.8 (T4A)			
Nectran	*Salmo gairdneri*	BSA	–	7,000 (T 18 hr)	a	The experiment was conducted at 55 F. Fish were 2-3 in. long.	Cope (1963)
Neguvon	*Salmo gairdnerii*	BSA	–	12.2 (T2A)	a f	Variance and the 95-percent confidence interval (C.I.) were also determined.	Willford (1966)
	Salmo trutta			16.5 (T2A)			
	Salvelinus fontinalis			16.8 (T2A)			
	Salvelinus namaycush			9.0 (T2A)			
	Ictalurus punctatus			32.0 (T2A)			
	Lepomis macrochirus			71.0 (T2A)			
Nemagon	*Lepomis macrochirus*	BSA	–	20 (T2A)	a c o	The response of bluegill and bass fingerlings to nine agricultural chemicals as determined by bioassay using river water is presented in this report. Bluegills were more tolerant of the chemicals tested than bass.	Davis and Hardcastle (1959)
	Micropterus salmoides			20 (T2A)			
Neotran	Channel catfish (fingerlings)	BSA	–	146 (K1A)	a	Tap water was used. Considerable addtional data are presented.	Clemens and Sneed (1959)
Nigrosine	*Daphnia magna*	L	–	(O)	a	Aquaria were treated with 1.2, 2.4, 3.6, and 7.2 ppm nigrosine, corresponding to 10, 20, 30, and 60 pounds per acre. It was shown that *Daphnia* could survive the 7.2 ppm concentration for at least 5 days and probably for much longer.	Surber (1943)

N-Serve	Oyster	BCF	–	0.28 (O)	a	The value reported is a 96-hr EC_{50} (decreased shell growth).	Butler (1965)
	Penaeus aztecus	L	–	(O)	a	Toxicant chemicals were evaluated in seawater at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality. No effect occurred at 1.0 ppm.	
	Leiostomus xanthurus (juvenile)	BSA	–	(O)	a	Water temperature was 16 C. No effect was noticed on exposure to 1.0 ppm.	
N-Serve	*Crassostrea virginica*	BCFA & BSA	–	0.28 (O)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
	Penaeus aztecus			1.0 (NTE)			
	Leiostomus xanthurus			1.0 (NTE)			
	Phytoplankton			15% (O)			
Nonic 218	*Semotilus atromaculatus*	BSA	–	20 to 60 (CR)	a e	Test water used was freshly aerated Detroit River water. A typical water analysis is given. Toxicity is expressed as the "critical range" (CR), which was defined as that concentration in ppm below which the 4 test fish lived for 24 hr and above which all test fish died. Additional data are presented.	Gillette, et al (1952)
Noxfish (5.0% rotenone, 10.0% cube extracts emulsifier)	*Cyprinus carpio*	BSA	–	0.081 (T3A)	a c d e i	Such variables as temperature, species, and size of fish were studied. Toxicity is expressed as LD_{50} for 72 hr. Smaller concentrations of rotenone were required when used in conjunction with sulfoxide. The data shown are for 70 F. The chemical was considerably more toxic at this temperature than at 40 F for all fish species.	Hester (1959)
	Micropterus salmoides			0.147 (T3A)			
	Pimephales promelas			0.159 (T3A)			
	Carassius auratus			0.175 (T3A)			
	Lepomis macrochirus			0.179 (T3A)			
	L. cyanellus			0.165 (T3A)			
	Notemigonus crysoleucas			0.470 (T3A)			
	Ictalurus nebulosus marmoratus			0.247 (T3A)			
Noxfish (5% rotenone)	*Cyprinus carpio*	BSA	–		a	Toxicity is reported as LD_{50} in ppm, at 75 F.	Hester (1959)
	(eggs)			0.091 (O)			
	(fry)			0.081 (O)			
	Pimephales promelas						
	(eggs)			0.142 (L)			
	(fry)			0.159 (L)			

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Nytron	*Penaeus aztecus*	L	–	0.0015 (O)	a	Toxicant chemicals were evaluated in sea water at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality.	Butler (1965)
Oil, crude	*Daphnia magna*	BSA	–	10,000 (T1A) 4,613 (T2A) 752 (T3A)	e	This study is concerned with waste oil emulsifiers.	Dowden (1962)
Omazene	*Onchorynchus tshawytscha*	BSA	–	0.83 (T1A) 0.83 (T2A)	a c d e	Concentrations were based on percent active ingredient.	Bond, et al (1960)
OMPA (70%)	*Pimephales promelas*	BSA	–	135 (T4A)	a c d e f	Tests were performed in both hard and soft water. Additional tolerance limit values are given.	Henderson and Pickering (1958)
OMPA	Fathead minnow	BSA	–	135 (T4A)	a	It was the authors opinion that pH, alkalinity and hardness, within the usual range in natural waters, had little effect on the toxic effect of the compounds studied. The values given are from Henderson, Pickering, and Tarzwell, "The Relative Toxicity of Ten Chlorinated Hydrocarbon Insecticides to Four Species of Fish". It is interesting that the different tables from the above book (as reported in this paper) report widely different values for the same compounds.	Tarzwell (1959)
OMPA	*Pimephales promelas*	BSA	–	121 (T4A)	a d e f	This experiment was performed in hard water. Concentrations were based on percent active ingredient.	Henderson, et al (1960)
OMPA	*Pimephales promelas*	BSA	–	121 (T4A)	a	Bioassay investigations of the new insecticides indicate that in general the organic phosphorus compounds are not as toxic to fish as are the chlorinated hydrocarbons. The toxicity of most of these materials was not significantly influenced by water quality. Therefore it is to be expected that the toxicity of these materials will not differ significantly in different streams.	Tarzwell (1959)
OMPA (tech, 90 percent)	*Pimephales promelas*	BSA	–	88 (T4A)	a c d e	Soft water primarily was the test medium. TL_m's reported for 24, 48, and 96 hr. Acetone or alcohol used as solvent or carrier in most cases.	Pickering, et al (1962)
	Lepomis macrochirus			120 (T4A)			
	Carassius auratus			680 (T4A)			
	Lebistes reticulatus			22 (T4A)			
OMS-3 (EC2)	*Gambusia affinis*	FL	Ponds in Ill.	(O)	–	When applied at 1.0 pound per acre active ingredient, 100 percent mortality occurred in 1 day.	Mulla, et al (1963)
OMS 44 (Bayer 37343)	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	–	0.4 (O)	a	Stones heavily populated with wild larvae were placed in troughs of running water containing the toxicant. When the larvae became detached from the rocks and floated away, they were assumed to have undergone lethal intoxication. The larvae were exposed to the toxicant for 5 minutes, then in clean water for 24 hours. At that time the number detached amounted to 89 percent.	Jamnback and Frempong-Boadu (1966)

OMS-115 (EC2)	*Gambusia affinis*	FL	Ponds in Ill.	(O)	—	When applied at 0.5 pound per acre active ingredient, 100 percent mortality occurred in 1 day.	Mulla, et al (1963)
OMS-144	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	—	0.4 (O)	a	Stones heavily populated with wild larvae were placed in troughs of running water containing the toxicant. When the larvae became detached from the rocks and floated away, they were assumed to have undergone lethal intoxication. The larvae were exposed to the toxicant for 5 minutes, then in clean water for 24 hours. At that time the number detached amounted to 8 percent.	Jamnback and Frempong-Boadu (1966)
OMS-315	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	—	4.0 (O)	a	Comment same as above except that at that time the number detached amounted to 35 percent.	Jamnback and Frempong-Boadu (1966)
OMS-437	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	—	0.4 (O)	a	Comment same as above except that at that time the number detached amounted to 61 percent.	Jamnback and Frempong-Boadu (1966)
OMS-595 (SD8447)	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	—	0.4 (O)	a	Comment same as above except that at that time the number detached amounted to 9 percent.	Jamnback and Frempong-Boadu (1966)
OMS-648	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	—	0.4 (O)	a	Comment same as above except that at that time the number detached amounted to 38 percent.	Jamnback and Frempong-Boadu (1966)
OMS-658	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	—	4.0 (O)	a	Comment same as above except that at that time the number detached amounted to 35 percent.	Jamnback and Frempong-Boadu (1966)
OMS-659	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	—	0.4 (O)	a	Comment same as above except that at that time the number detached amounted to 44 percent.	Jamnback and Frempong-Boadu (1966)
OMS-711	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	—	0.4 (O)	a	Comment same as above except that at that time the number detached amounted to 10 percent.	Jamnback and Frempong-Boadu (1966)
OMS-712	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	—	0.4 (O)	a	Comment same as above except that at that time the number detached amounted to 9 percent.	Jamnback and Frempong-Boadu (1966)
OMS-754	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	—	4.0 (O)	a	Comment same as above except that at that time the number detached amounted to 15 percent.	Jamnback and Frempong-Boadu (1966)
OMS-868	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	—	0.04 (O)	a	Comment same as above except that at that time the number detached amounted to 11 percent.	Jamnback and Frempong-Boadu (1966)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
OMS-669	*Prosimulum* spp *Cnephia* spp *Simulium* spp (larvae)	LCFA	–	4.0 (O)	a	Stones heavily populated with wild larvae were placed in troughs of running water containing the toxicant. When the larvae became detached from the rocks and floated away they were assumed to have undergone lethal intoxication. The larvae were exposed to the toxicant for 5 minutes, then in clean water for 24 hours. At that time the number detached amounted to 13 percent.	Jamnback and Frempong-Boadu (1966)
Organochlorines (pp'-DDT, pp'-DDE, HEOD, Endrin)	*Ammodytes lanceolatus* *Phalacrocorax aristotelis* *Phalacrocorax carbo* *Gadus morrhua* *Mytilus edulis* *Somateria mollissima* *Cardium edule* *Pastella vulgata* *Homarus vulgaris* *Calcinus maenas* *Cancer pogurus* *Pleuronectes* sp *Clupea harengus* *Gadus merlangus* *Sula bassana* *Halichoerus grypus* *Delphinus delphis*	FO	Britain	(O)	–	Residues of organochlorine insecticides tended to be greater in marine organisms of the higher trophic levels, but the tendency was not found in all food chains.	Robinson, et al (1967)
Organo-phosphorus pesticides	*Leiostomus xanthurus* *Cyprinodon variegatus*	FECH	Atlantic and Gulf Coasts	(O)	–	Describes method to detect low level concentration of pollution by measuring the degree of inhibition of acetyl cholinesterase (AChE). Of 93 samples from 43 stations, 17 showed less than 90% of normal AChE activity.	Holland, et al (1967)
Ortho 5305 EC2	*Gambusia affinis*	FL	Cal.	0.8 (K1)	–	At a concentration of 0.2 lb/acre, 88% mortality of the fish occurred in 24 hours. At 0.8 lb/acre, 100% mortality occurred.	Mulla (1966)

Ortho 5353 EC2	*Gambusia affinis*	FL	Col.	1.0 (K1)	–	Toxicity value is in lb/acre.	Mulla (1966)
Ovex, Tech.	Rainbow trout	BSA	–	0.620 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
Ovex	*Pimephales promelas*	BSA	–	2.5 (T4A)	a c d e f	The toxicity of this substance was not influenced by the quality of the water (pH, hardness, alkalinity).	Pickering and Henderson (1966)
Oxydemeton-methyl	*Pteronarcys californica* (naiads)	BSA	–	0.035 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Paramar-50	*Cyprinus carpio*	BSA	–	6.5 (T2A)	a c d e f p	The test animals were conditioned for 48 hours prior to use.	Sreenivasan and Swanithan (1967)
	Tilapia massambica			4.0-5.0 (T2A)			
	Cirrhina mrigala			5.0 (T2A)			
	Labeo fimbriatus			7.5 (T2A)			
	Barbus machecola			2.0 (T2A)			
Para-oxon	*Pimephales promelas*	BSA	–	0.33 (T4A)	a c d e f	Tests were performed in both hard and soft water. Additional tolerance limit values are given.	Henderson and Pickering (1958)
Para-oxon	Fathead minnow	BSA	–	.25 (T4A)	a	It was the authors opinion that pH, alkalinity and hardness, within the usual range in natural waters, had little effect on the toxic effect of the compounds studied. The values given are from Henderson, Pickering, and Tarzwell, "The Relative Toxicity of Ten Chlorinated Hydrocarbon Insecticides to Four Species of Fish". It is interesting that the different tables from the above book (as reported in this paper) report widely different values for the same compounds. This experiment was performed in hard water.	Tarzwell (1959)
Para-oxon	*Pimephales promelas*	BSA	–	0.33 (T4A)	a d e f	Concentrations were based on percent active ingredient.	Henderson, et al (1959)
Para-oxon	*Pimephales promelas*	BSA	–	0.33 (T4A)	a	Bioassay investigations of the new insecticides indicate that in general the organic phosphorus compounds are not as toxic to fish as are the chlorinated hydrocarbons. The toxicity of most of these materials was not significantly influenced by water quality. Therefore it is to be expected that the toxicity of these materials will not differ significantly in different streams.	Tarzwell (1959)
Paraoxon	*Lepomis gibbosus*	BSA	–	2/4 (O)	–	The figures given are for mortality in 2 hours when the amount of chemical was 16 mg/kg, given by injection.	Murphy (1966)
Paraoxon	*Lepomis gibbosus*		–	0.120 ± 0.022 (O)	–	This paper is a study of the amounts of organic thiophosphate and their oxygen analogues which accumulate in liver slices in an *in vitro* study of insecticides. The numbers given are for mμm of chemical (in the case of Parathion, Malathion, and Guthion—the oxygen analogue) accumulated in 50 mg of liver (wet weight) in 10 minutes.	Murphy (1966)
	Ictalurus melas			0.122 ± 0.005 (O)			
	Pseudopleuronectes americanus			0.041 ± 0.006 (O)			
	Myxocephalus scorpius			0.076 ± 0.010 (O)			

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Paraquat (cation)	*Lepomis macrochirus*	BSA	–	400 (T1A)	–	The bioassay methods employed in this experiment were not given in the paper but it was stated that the same procedures were employed as in previous work.	Davis and Hughes (1963)
Paraquat	*Lepomis macrochirus*	BSA	–	5 (O)	–	Toxicity to fish was determined as the threshold concentration (LD_{10}) in 96 hr at 75 F (65 F for trout). Herbicidal evaluations are also presented.	Lawrence, et al (1965)
	Micropterus salmoides			5 (O)	–		
	Pimephales promelas			5 (O)	–		
	Ictalurus punctatus			5 (O)	–		
	Salmo gairdnerii			5 (O)	–		
Paraquat	*Spirodela polyrhyza*	BSA	–	(O)	a	0.01 ppm caused 82% chlorosis in 7 days.	Blackburn and Weldon (1965)
	Lemna minor					0.01 ppm caused 72% chlorosis in 7 days.	
	Wolffiella floridana					0.01 ppm caused 62% chlorosis in 7 days.	
	Azolla caroliniana					0.01 ppm caused 40% chlorosis in 7 days.	
	Wolffia columbiana					0.01 ppm caused 3% chlorosis in 7 days. Light intensity was kept at 500 foot-candles for 14 hours per day. Light has been shown to increase the rate of kill with paraquat. Test containers were plastic petri dishes.	
Paraquat	*Lemna minor* *Spirodela polyrhyza* *Wolffia columbiana*	FL	Fla.	(O)	–	Common duckweed and watermeal in small ponds can be controlled with paraquat at rates as low as 0.25 ppmw, but rates greater than 0.5 ppmw are required for control in ponds infested with watermeal.	Blackburn and Weldon (1965)
Paraquat	*Fundulus similis* (juvenile)	BSA	–	(O)	a	Water temperature was 19 C. No effect was noticed on exposure to 1.0 ppm.	Butler (1965)
Paraquat	Oyster	BCF	–	(O)	a	No effect on exposure to the chemical at 1.0 ppm.	Butler (1965)
Paraquat	*Penaeus aztecus*	L	–	(O)	a	Toxicant chemicals were evaluated in sea water at temperatures averaging about 28 C. The values for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality. No effect occurred at 1.0 ppm.	Butler (1965)

Paraquat	*Crassostrea virginica* *Penaeus aztecus* *Fundulus similis* Phytoplankton	BCFA & BSA	–	1.0 (NTE) 1.0 (NTE) 1.0 (NTE) 53% (O)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
Paraquat	*Pteronarcys* sp (nymphs)	BSA	–	>1000 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Paraquat	*Daphnia magna*	BSA	–	11.0 (9.1-12.2) (O)	a c d i q	Toxicity, in terms of median immobilization concentration (IC_{50}), is presented.	Crosby and Tucker (1966)
Paraquat	*Simocephalus serrulatus* *Daphnia pulex*	BSA	–	4.0 (SB) 3.7 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
Paraquat	*Pteronarcys californica* (naiads)	BSA	–	100 (NTE)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Parathion	Bluegill Rainbow trout Brown trout	BSA	–	(O)	–	A concentration of 0.2 ppm was near the concentration threshold for bluegills. Concentrations of 0.063, 0.189, and 0.378 ppm did not kill 1-inch rainbow and brown trout.	Linduska and Surber (1948)
Parathion (15 percent) 0,0-Diethyl-o-p-nitrophenyl thiophosphate)	Lymnaeid snails	BSA	–	(O)	–	Each test container, 500-ml beaker, was filled with ditch water. 100% mortality occurred in concentrations of 1:400,000 and greater.	Batte, et al (1951)
Parathion	*Simulium* sp (larvae)	FR	Streams, S. C. and Fla.	0.5-1.0 (O)	–	In slow-moving streams in Florida, parathion at the indicated concentrations eliminated blackfly larvae for distances up to 1.6 miles. In South Carolina, 100 percent reductions for distances of up to 2.8 miles was obtained. Data are presented as percent larval detachment in 1, 2, and 3-days time.	Davis, et al (1957)
Parathion (20% tech, parathion and 80% triton X-100)	Rainbow trout Eastern brook trout	BCFA	–	0.05-1.0 (K 0%)	a	Spring water (46 F) was used. This flow rate was 10 GPM. The chemical was added by continuous drip dispenser. 0.01 ppm kill mosquito larvae.	Hoffman (1957)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Parathion	Various	FL	Salt Lake Co., Utah	(O)	–	The chemical was applied at 0.05 lb/acre. Careful application of the chemical at the above concentration controlled mosquito larvae without loss of fish. At the above concentration no adverse effects were observed in mammals, birds, reptiles, and amphibians although some frogs were killed by the application of parathion at several times the normal concentration. Invertebrates were not affected uniformly. Crustaceans were not harmed, nor were larvae of the insect family Ephydridae. Spiders and aquatic insects other than Ephydridae were adversely affected in varying degrees. Aquatic beetles seemed to be affected more seriously than other insects excepting mosquito larvae.	Graham and Anderson (1958)
Parathion	*Pimephales promelas* *Lepomis macrochirus*	BSA	–	1.4 (T4A) 0.71 (T4A)	a c d e f	Tests were performed in both hard and soft water. Additional tolerance limit values are given.	Henderson and Pickering (1958)
Parathion	*Artemia salina*	BSA	–	0.43 (L < 1)	a i	Rock salt was used in rearing all cultures employed in bioassay work. The optimum salt concentration was 3.5%.	Tarpley (1958)
Parathion	Fathead minnow	BSA	–	1.6 (T4A)	a	It was the authors opinion that pH, alkalinity and hardness, within the usual range in natural waters, had little effect on the toxic effect of the compounds studied. The values given are from Henderson, Pickering, and Tarzwell, "The Relative Toxicity of Ten Chlorinated Hydrocarbon Insecticides to Four Species of Fish". It is interesting that the different tables from the above book (as reported in this paper) report widely different values for the same compounds.	Tarzwell (1959)
Parathion	*Daphnia magna*	BSA	–	0.0008 (O)	a	The indicated concentration immobilized *Daphnia* in 50 hours.	Anderson (1960)
Parathion	*Pimephales promelas*	BSA	–	1.4 (T4A)	a d e f	Concentrations were based on percent active ingredient.	Henderson, et al (1960)
Parathion	*Gambusia affinis*	BSA	–	0.004 (K 33%)	a	Chemicals were dissolved in acetone, and tests were run in triplicate. Toxicity is given as avg. percent fish killed in 24 hr.	Lewallen (1959)
Parathion	*Pimephales promelas*	BSA	–	1.4 (T4A) 0.700 (T4A)	a	Bioassay investigations of the new insecticides indicate that in general the organic phosphorus compounds are not as toxic to fish as are the chlorinated hydrocarbons. The toxicity of most of these materials was not significantly influenced by water quality. Therefore it is to be expected that the toxicity of these materials will not differ significantly in different streams.	Tarzwell (1959)
Parathion	*Lepomis macrochirus* *Micropterus salmoides* *Notemigonus crysoleucas*	BSA	–	0.1 (O) 0.1 (O) 0.1 (O)	a c d f	This paper reports the effect of insecticides in reducing the anticholinesterase in a fish brain within 2-8 hours. The inhibition of the enzyme was a function of the concentration of the insecticide, extent of exposure, and specific chemical nature of the compound.	Weiss (1959)

	Carassius auratus			0.1 (O)			
Parathion, (tech, 25% active in xylene)	*Acroneuria pacifica*	BSA	–	0.0001 (T4A)	a c e f l n	Assays were conducted in hard water.	Gaufin (1961)
	Pteronarcys californica			0.0032 (T4A)			
	Arctopsyche grandis			0.001 (T4A)			
Parathion (tech grade emulsified in exlene)	*Hydropsyche californica*	BSA	–	0.00043 (T4A)	a c d e l m	Test water was obtained from a mountain stream.	Gaufin, et al (1961)
	Acroneuria pacifica			0.001 (T4A)			
	Arctopsyche grandis			0.007 (T4A)			
	Pteronarcys californica			0.0086 (T4A)			
Palathion (50 percent EC)	*Gambusia affinis*	FL	Ponds—Bakersfield, Cal.	(O)	a c	At 0.1 lb/acre, 22 percent mortality occurred in 24 hours. At 0.4 lb/acre, 92 percent mortality occurred in 24 hours. The experiments were conducted in cages placed in the ponds.	Mulla and Isaak (1961)
Parathion	*Anopheles quadrimaculatus*	BSA	–	0.01 (K1)	–	4th instar larvae of mosquitos were used in this bioassay. At the indicated concentrations, the following mortalities occurred: *Anopheles quadrimaculatus* 94% *Aedes aegypti* 52% *A. taeniorhynchus* 78% Adsorption was determined by use of P^{32} labeled parathion.	Schmidt and Weidhaas (1961)
	Aedes aegypti			0.005 (O)			
	A. taeniorhynchus			0.005 (O)			
Parathion	*Micropterus salmoides*	BSA	–	0.5 (O)	–	The degree of reaction to the cholinesterase-inhibiting insecticides is not only a function of time and concentration, but also of chemical and biological species. This paper reports many analyses of brain cholinesterase activity which is expressed as percentage of normal. The data are reported as LT_{50} which was the time required for 0.5 ppm of the chemical to kill 50 percent of the fish. For bass the LT_{50} was 24 hr and for the fathead 72 hr.	Weiss (1961)
	Pimephales promelas			0.5 (O)			
Parathion	*Salmo gairdnerii* (one wk. old sac fry)	BSA	–	0.2 (K 0%) 2.0 (K 0%)	a e	Results are averages of triplicate tests. Toxicity is reported as percent mortality (K %).	Lewallen and Wilder (1962)
	(one mo. old feeding fry)	BSA	–	0.2 (K 0%) 2.0 (K 80%)			
Parathion, (tech, 99 percent)	*Pimephales promelas*	BSA	–	1.3 (T4A)	a c d e	Soft water primarily was the test medium. TL_m's reported for 24, 48, and 96 hr. Acetone or alcohol used as solvent or carrier in most cases.	Pickering, et al (1962)
	Lepomis macrochirus			0.095 (T4A)			
	Carassius auratus			2.7 (T4A)			
	Lebistes reticulatus			0.056 (T4A)			

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Parathion, emulsible concentrate (25 percent)	*Pimephales promelas*	BSA	—	3.0 (T4A)	a c d e	Soft water primarily was the test medium. TL_m's reported for 24, 48, and 96 hr. Acetone or alcohol used as solvent or carrier in most cases.	Pickering, et al (1962)
	Lepomis macrochirus			Large 0.58 (T4A) Small 0.26 (T4A)			
	Carassius auratus			2.6 (T4A)			
	Green sunfish			1.7 (T4A)			
	Largemouth bass			0.76 (T4A)			
Parathion	*Culex pipiens quadrimaculatus*	BSA	—	(O)	c	Tests were conducted in tap water and artificially polluted tap water. The values reported are the concentration range for an LC_{90}, 0.034 to 0.1100 ppm for polluted and 0.0072 to 0.0140 ppm for tap water.	Lewallen and Wilder (1963)
Parathion (EC2)	*Gambusia affinis* *Bufo boreas* *Scaphiopus hammondi*	FL	Ponds in Ill.	(O)	—	When applied at 0.4 pounds per acre active ingredient, 96 percent fish mortality occurred in 1 day. No toad mortality occurred at 0.4 pound per acre in 1 day.	Mulla, et al (1963)
Parathion (tech, 95 percent active in acetone)	*Pteronarcys californica* (naiad)	BSA	—	0.0320 (T4A)	c d e f	*A. pacifica* was much more sensitive to chlorinated hydrocarbons and to organic phosphate insecticides than *P. californica*.	Jensen and Gaufin (1964)
	Acroneuria pacifica (naiad)			0.0028 (T4A)			
Parathion	*Gammarus lacustris*	BSA	—	0.0128 (T4A)	a e	Emulsible concentrates were prepared from technical grade insecticides with acetone as the solvent. Symptoms prior to death were observed and recorded on graphs.	Nebeker and Gaufin (1964)
Parathion	Bluegill	BSA	—	0.095 (T4A)	a	Assays were conducted in soft water at 25 C. Decrease in brain cholinesterase was measured in fish exposed to the toxicant.	Weiss (1964)
Parathion	*Carassius auratus* *Lepomis macrochirus* *Notemigonus crysoleucas*	BSCH	—	10.0 (O)* 1.0 (O)* 0.1 (O)** 0.1 (O)*** 10.0 (O)* 1.0 (O)* 0.1? (O)* 0.1 (O)*** *response, 15 days **no response, 15 days ***no response, 30 days	a c d e	Toxicity was determined by measuring acetylcholinesterase activity in the brains of fish. Concentrations are given in ppb as either response or no response in 15 or 30 days.	Weiss and Gakstatter (1964)

Parathion	*Acroneuria pacifica*	BSA	—	0.0028 (T4A)	a c	Additional TL_m data are given.	Gaufin, et al (1965)
	Ephemerella grandis			0.003 (T4A)			
	Gammarus lacustris			0.0128 (T4A)			
	Pteronarcys californica			0.032 (T4A)			
Parathion	*Arctopsyche grandis*	BSA	—	0.007 (T4A)	a	Unspecified chemical characteristics of assay water were determined by standard methods. General comments were made concerning "standardized" conditions, use of "soft" water, and use of emulsifying agents. Additional data are presented.	Gaufin, et al (1965)
	Pteronarcys californica			0.03 (T4A)			
	Acroneuria pacifica			0.003 (T4A)			
	Ephemerella grandis			0.003 (T4A)			
	Hydropsyche californica			0.0004 (T4A)			
	Daphnia magna			0.0008 (T 50 hr A)			
	Gammarus lacustris			0.01 (T4A)			
	Bluegill sunfish			0.06 (T4A)			
	Fathead minnow			1.4 (T4A)			
Parathion	*Lepomis gibbosus*	BSA	—	0/4 (O)	—	The figures given are for mortality in 2 hours when the amount of chemical was 40 mg/kg, given by injection: number dead/number injected.	Murphy (1966)
Parathion	*Lepomis gibbosus*		—	19.97 ± 7.09 (O)	—	This paper is a study of the amounts of organic thiophosphate and their oxygen analogues which accumulate in liver slices in an *in vitro* study of insecticides. The numbers given are for mμm of chemical (in the case of Parathion, Malathion, and Guthion—the oxygen analogue) accumulated in 100 mg (dry weight) of liver in 30 minutes.	Murphy (1966)
	Ictalurus melas			14.52 ± 1.56 (O)			
	Pseudopleuronectes americanus			5.20 ± 0.81 (O)			
	Myxocephalus scorpius			0.4 ± 0.2 (O)			
Parathion	Sewage organisms	BOD	—	(O)	—	Shock loadings of the chemical as high as 15.0 mg/l were assimilated by microbial systems of 500.0 mg/l with no observable toxic effect. Organophosphate insecticides in low concentration stimulated microbial respiration; however, greater concentrations inhibited the system and eventually destroyed the organisms. The amount of organophosphate insecticide required to inhibit the respiration of freshwater microorganisms was shown to be function of the amount of organisms present and not the volume of water in which the organisms are dispersed.	Randall (1966)
Parathion	*Simocephalus serrulatus* *Daphnia pulex*	BSA	—	0.00037 (SB)	—	Concentration reported is for immobilization. Time for immobilization was 48 hr. Data cited are for 60 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)

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Parathion	*Tubifex* spp *Limnodrilus* spp	BSA	–	5-2 (L4A)	a c e	Toxicity is reported as the mean lethal dose (LD_{50}) for 24, 48, and 96 hours.	Whitten and Goodnight (1966)
Parathion	*Leiostromus xanthurus*	BCFCH	–	0.01 (O)	a	At a concentration of .01 ppm, the following percent acetylcholinesterase activity as compared to controls was found: *L. xanthurus* –10 *C. variegatus* –26	Butler and Johnson (1967)
	Cyprinodon variegatus			0.01 (O)			
Parathion	*Micropterus salmoides*	BSA	–	2.0 (O) 5.0 (K 3 hr)	a e	At 2.0 ppm, 40 percent mortality occurred in 1 day. Experiments were carried out in plastic tubs lined with saran plastic. Fish weights averaged 217 grams.	Mulla, et al (1967)
Parathion	*Pteronarcys californica* (naiads)	BSA	–	0.0054 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Parathion	*Pteronarcys californica* (naiads)	BSA	–	0.0054 (T4A)	a c d e f	Comment same as above.	Sanders and Cope (1968)
	Pteronarcella badia (naiads)			0.0042 (T4A)			
	Claasenia sabulosa (naiads)			0.0015 (T4A)			
Parathion	*Lepomis macrochirus*	BSSB	–	0.0075, 0.032, and 0.087 (O)	a c f	Critical flicker frequency response in the bluegill was measured by determining this species ability to maintain position relative to continuously rotating stripes. Increasing or decreasing the rate of movement of the stripes above or below a certain critical flicker threshold caused the fish to return to random swimming. The effect of different amounts of insecticide was measured. An aberrant response was noted at all three sublethal concentrations noted.	Scheier and Cairns (1968)
Parathion	*Lepomis gibbosus* *Ictaluras melas* *Micropterus dolomieui* *Myxocephalus scorpius* *Pseudopleuronectes americanus*	BSA	–	(O)	a p	The chemicals were poor inhibitors of brain cholinesterases *in vitro;* their oxygen analogs were potent inhibitors.	Murphy, et al (1968)
Parzate	Channel catfish (fingerlings)	BSA	–	21.1 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)

Penicillin G, potassium (crystalline)	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – PT (7) Ma – T So – NT Cv – NT Gp – NT Np – NT	Palmer and Maloney (1955)
Perthane	*Gambusia affinis*	BSA	–	10.4 (L1)* 10.0 (L1)** *Resistant fish **Nonresistant fish	a	This paper deals with the resistance of mosquito fish to chlorinated hydrocarbon compounds. Resistant fish were not always less sensitive to these chemicals.	Boyd and Ferguson (1964)
Perthane (tech)	Rainbow trout	BSA	–	0.005 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
Phorate (Thimet)	Oyster	BCF	–	0.64 (O)	a	The value reported is a 96-hr EC_{50} (decreased shell growth).	Butler (1965)
Phosdrin	Rainbow trout Eastern brook trout	BCFA	–	0.05 (K 3 day) 0.1 (K 4 hr) 0.5 (K 80 min) 1.0 (K 30 min) 10.0 (K 15 min)	a	Spring water (46 F) was used. The flow rate was 10 gpm. The chemical was added by continuous drip dispenser. 0.01 ppm for 180 hr showed toxic effects, but no kill.	Hoffman (1957)
Phosdrin (tech)	Rainbow trout Bluegill	BSA	–	0.012 (T4A) 0.023 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
Phosdrin	*Pteronarcys* sp (nymphs)	BSA	-	0.0049 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Phosdrin	*Simocephalus serrulatus* *Daphnia pulex*	BSA	–	0.00043 (SB) 0.00016 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 48 hr. Data cited are for 60 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
Phosdrin	*Pteronarcys californica* (naiads)	BSA	–	0.005 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Phosphamidon (tech)	*Procambarus clarki*	BSA	–	5.5 (T3A)	a c d o	There was no detectable difference in toxicity to male or female crawfish.	Muncy and Oliver (1963)
Phosphamidon	*Salmo gairdneri*	BSA	–	5,000 (T1A)	a	The experiment was conducted at 55 F. Fish were 2-3 in. long.	Cope (1963)
Phosphamidon	*Salmo gairdneri*	BSA	–	5,000 (T 18 hr)	a	Comment same as above.	Cope (1963)

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Phosphamidon	*Simocephalus serrulatus*	BSA	–	0.012 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 48 hr. Data cited are for 60 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
	Daphnia pulex			0.0088 (SB)			
	Daphnia magna	BSA	–	0.0125 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
Phosphamidon	Coho salmon (fry)	FR	Moran Creek, B.C.	7.0 (T2A)	a	The data indicated 1.0 to 3.2 ppm would cause a slight mortality of juvenile coho salmon. The value of 7.0 ppm was taken from a preliminary bioassay.	Schouwenberg and Jackson (1966)
Phosphamidon (in water)	Atlantic salmon Brook trout	FR	New Brunswick	(O)	–	Spraying with this chemical at 1.0 lb per acre had no apparent harmful effects on young salmon or trout.	Kerswill and Edwards (1967)
Phosphamidon	*Pteronarcys californica* (naiads)	BSA	–	0.15 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Phygon XL	*Oncorhynchus kisutch*	BSA	–	0.042 (NTE)	a c d e	Concentrations were based on percent active ingredient. No toxicity to *O. kisutch* occurred at concentrations up to 0.042 ppm.	Bond, et al (1960)
	Micropterus salmoides			0.08 (T1A) 0.07 (T2A)			
Phygon-XL	Channel catfish (fingerlings)	BSA	–	0.14 (K 29 hr A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Phygon-XL	*Salvelinus fontinalis x Salmo trutta* *Notemigonus crysoleucas*	FPA	N.Y.	0.5 (S23)	a c d	Conventional farm ponds were used having an average surface area of 0.3 acre and a maximum depth of 7-9 ft. Toxicity (in ppm) to fish as maximum safe concentration (S) for 23 days was determined. Concentration of 0.5 ppm was required to control algae.	Eipper (1959)
	Ictalurus punctatus			0.5 (S23)			
	Micropterus salmoides			0.5 (S23)			
	Lepomis macrochirus			0.5 (S23)			
Phygon-XL	*Salmo gairdneri*	BSA	–	0.075 (T1A) 0.075 (T2A)	a c d f g	Hatchery artesian well water was employed for this experiment.	Webb (1961)
Phygon X-L	*Richardsonius balteatus hydroflox*	BSA	–	0.13 (T1A) 0.11 (T2A) 0.11 (T4A)	a c d e f	Results given were in soft water. Results in hard water were as follows: 0.15 (T1A), 0.15 (T2A), and 0.14 (T4A).	Webb (1961)

Phygon-XL	*Gammarus lacustris*	BSA	–	0.165 (T4A)	a e	Emulsible concentrates were prepared from technical grade insecticides with acetone as the solvent. Symptoms prior to death were observed and recorded on graphs.	Nebeker and Gaufin (1964)
Phygon XL (Dichlone)	Salmon	BSA	–	0.043 (T2A)	–	Data are given as LC_{50}.	Bohmont (1967)
Picloram	*Pteronarcys californica* (naiads)	BSA	–	0.048 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
P M A	*Salmo gairdneri*	BSA	–	3.75 (T2A)	a f	Variance and the 95-percent confidence interval (C.I.) were also determined.	Willford (1966)
	Salmo trutta			6.22 (T2A)			
	Salvelinus fontinalis			10.7 (T2A)			
	Salvelinus namaycush			7.60 (T2A)			
	Ictalurus punctatus			2.89 (T2A)			
	Lepomis macrochirus			16.0 (T2A)			
Polyclens	*Pandalus montagni*	BSA	–	8.5 (T2A)	a e	Experiments were conducted in tanks holding 10 liters of seawater at 15 C. It was shown that the toxicity of this solvent emulsifier decreased with time due to evaporation of the solvent. Polyclens at a concentration of 3.3 ppm killed 100% of *Crangon crangon* larvae in 3 hr.	Portmann and Connor (1968)
	Crangon crangon			15.7 (T2A)			
	Carcinus maenas			23.2 (T2A)			
	Cardium edule			70.0 (T2A)			
Polysan	Guppy	BSA	–	100 (K 25 min)	a	Those fish that survived at lower concentrations were still very active several days after they had been taken out and placed in fresh water.	Anonymous (1964)
Prometone [2-methoxy-4,6-bis(isopropylamino)-s-triazine (prometone)]		BSA	–		a	Experiments were conducted in standing water. Results were rated on a scale of 0 to 10, 0 standing for no toxic effect and 10 signifiying a complete kill. Evaluation was based on visual observation of the plant response at weekly intervals for 4 weeks.	Frank, et al (1961)
	Elodea canadensis			5 (O)		Injury rating of 0.5.	
				100 (O)		Injury rating of 3.6.	
	Potamogeton nodosus			5 (O)		Injury rating of 2.3.	
				100 (O)		Injury rating of 7.0.	
	Potamogeton pectinatus			5 (O)		Injury rating of 5.1.	
				100 (O)		Injury rating of 8.3.	
Prometone	*Leiostomus xanthurus* (juvenile)	BSA	–	(O)	a	Water temperature was 26 C. No effect was noticed on exposure to 1.0 ppm.	Butler (1965)
Prometone	*Penaeus duorarum*	L	–	(O)	a	Toxicant chemicals were evaluated in sea water at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality. No effect occurred at 1.0 ppm.	Butler (1965)
Prometone	Oyster	BCF	–	(O)	a	No effect on exposure to the chemical at 1.0 ppm.	Butler (1965)

Chemical	Organism	Bioassay or Field Study$^{(1)}$	Field Location$^{(2)}$	Toxicity, Active Ingredient, ppm$^{(3)}$	Experimental Variables Controlled or Noted$^{(4)}$	Comments	Reference (Year)
Prometone	*Crassostrea virginica*	BCFA & BSA	–	1.0 (NTE)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
	Penaeus duorarum			1.0 (NTE)			
	Leiostomus xanthurus			1.0 (NTE)			
	Phytoplankton			–			
Prometryne	Oyster	BCF	–	(O)	a	Exposure to a concentration of 1 ppm caused a 19.0% decrease in shell growth.	Butler (1965)
	Leiostomus xanthurus (juvenile)	BSA				Water temperature was 28 C. No effect was noticed on exposure to 1.0 ppm.	
Prometryne	*Peneas duorarum*	L	–	(O)	a	Toxicant chemicals were evaluated in sea water at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality. No effect occurred at 1.0 ppm.	Butler (1965)
Prometryne	*Crassotrea virginica*	BCFA & BSA	–	1.0 (0, 19%)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
	Penaeus duorarum			1.0 (NTE)			
	Leiostomus xanthurus			1.0 (NTE)			
	Phytoplankton			–			
Pro-noxfish (25% rotenone + 2.5% sulfoxide)	*Cyprinus carpio*	BSA	–		a	Toxicity is reported as LD_{50} in ppm, at 75 F.	Hester (1959)
	(eggs)			0.178 (K)			
	(fry)			0.163 (K)			
	Pimephales promelas						
	(eggs)			0.233 (K)			
	(fry)			0.191 (K)			
Pro-noxfish (2.5% rotenone, 2.5% sulfoxide, 5% cube extracts emulsifier)	*Cyprinus carpio*	BSA	–	0.163 (K3)	a c d e i	Such variables as temperature, species, and size of fish were studied. Toxicity is expressed as LD_{50} for 72 hr. Smaller concentrations of rotenone were required when used in conjunction with sulfoxide. The data shown are for 70 F. The chemical was considerably more toxic at this temperature than at 40 F for all fish species.	Hester (1959)
	Micropterus salmoides			0.081 (K3)			
	Pimephales promelas			0.191 (K3)			
	Carassius auratus			0.242 (K3)			

	Lepomis macrochirus			0.255 (K3)			
	L. cyanellus			0.238 (K3)			
	Notemigonus crysoleucas			0.555 (K3)			
	Ictalurus nebulosus marmoratus			0.410 (K3)			
Pro-noxfish	*Oncorhynchus kisutch* (eggs)	FR	Ore.	(O)	a	Pro-noxfish is a formulation containing 2.5% rotenone, 5.0% related rotenoids and cube extractives, 2.5% sulfoxide synergists, and 90% solvent emulsifier. The goal of this experiment was to expose the eggs to the chemical at a concentration of 2 ppm for 24 hr. High survival occurred where the temperatures ranged from 46 to 56 F. High temperatures of 60 and 65 F occurred in Middle Fork and Quartzville Creek and contributed to the mortality rate. No eggs survived.	Garrison (1968)
Pro-noxfish	*Oncorhynchus tshawytscha* (fry, 100-day old) *Oncorhynchus kisutch* (eggs)	BSA	Corvallis, Ore.	0.15 to 5.0 (K1) (O)	a e	Pro-noxfish is a formulation containing 2.5% rotenone, 5.0% related rotenoids and cube extractives, 2.5% sulfoxide synergists, and 90% solvent emulsifier. Experiments were conducted in aerated test jars. Temperature was 53 F. Temperature seems to have an influence upon toxicity. Embryos exposed to the chemical for 24 hr showed the following survival rates. All embryos survived in 1.0 ppm at 53 F, all survived in 3 ppm at 46 F, and 90% survived in 4 ppm at 39 F.	Garrison (1968)
Propanil (Stam, Rogue)	*Daphnia magna*	BSA	–	4.8 (3.8-6.6) (O)	a c d i q	Toxicity, in terms of median immobilization concentration (IC_{50}), is presented.	Crosby and Tucker (1966)
Pyrethrin	*Pteronarcys* sp (nymphs)	BSA	–	0.001 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Pyrethrins	*Simocephalus serrulatus* *Daphnia pulex*	BSA	–	0.042 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 48 hr. Data cited are for 60 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
Pyrethrins	*Salmo gairdneri*	BSA	–	0.054 (T2A)	a	This paper reports acute toxicity of a number of compounds, and discusses sub-acute mortality as well. Effects on reproduction and behavior are also discussed. Data presented as EC_{50}.	Cope (1966)
	Lepomis macrochirus			0.070 (T2A)			
	Ictalurus punctatus			0.082 (T2A)			
	Pteronarcys californicus			0.006 (T2A)			
	Daphnia pulex			0.025 (T2A)			
	Simocephalus serrulatus			0.042 (T2A)			

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Pyrethrum	Black fly (larvae)	FR	Alaskan streams	0.1 (O)	–	The chemical was applied to control black flies, and because the acetone solution was most effective, only that data is reported here. The figures reported are for minimum effective dosages for black fly larvae and maximum nonlethal dosage for rainbow trout.	Gjulian, et al (1949)
	Rainbow trout			0.1 (O)			
Pyrethrum	*Salmo gairdnerii*	BSA	–	54 (T4A)	a c d	Toxicity values reported as median lethal concentration (LC_{50}) for 24, 48, and 96 hr.	Bridges and Cope (1965)
	Ictalurus punctatus			80 (T4A)			
	Lepomis macrochirus			74 (T4A)			
	Pteronarcys californica			1.0 (T4A)			
Pyrethrum	*Pteronarcys californica* (naiads)	BSA	–	0.0010 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Quaternary ammonium salt, commercial	*Microcystis aeruginosa*	L	–	2.0 (K)	a, etc	The chemical was tested on a 5-day algae culture, 1 x 10^6 to 2 x 10^6 cells/ml, 75 ml total volume. Chu No. 10 medium was used.	Fitzgerald, et al (1952)
Rivanol	Channel catfish (fingerlings)	BSA	–	2.8 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Roccal	*Micropterus salmoides* (fry)	BSA	–	1.0 (SB3)	a c d e f p	At least 90 percent of the fry survived for a period of 72 hours at the concentration listed.	Jones (1965)
	Ictalurus punctatus (fry)			1.0 (SB3)			
	Lepomis macrochirus (fry)			0.25 (SB3)			
Roccal	Guppy	BSA	–	100 (K1)	a	Those fish that survived at lower concentrations were still very active several days after they had been taken out and placed in fresh water.	Anonymous (1964)
Roccal	*Salmo gairdneri*	BSA	–	2.57 (T2A)	a f	Variance and the 95-percent confidence interval (C.I.) were also determined.	Willford (1966)
	Salmo trutta			2.05 (T2A)			
	Salvelinus fontinalis			3.40 (T2A)			
	Salevelinus namaycush			1.95 (T2A)			
	Ictalurus punctatus			1.12 (T2A)			
	Lepomis macrochirus			1.68 (T2A)			

Ronnel	*Chaoborus astictopus*	BSA	–	0.046 (T1A)	a	Toxicity value given is for the fourth instar larvae.	Hazeltine (1963)
Ronnel (EC2)	*Gambusia affinis* *Bufo boreas*	FL	Ponds in Ill.	(O)	–	When applied at 0.8 pound per acre active ingredient, no fish mortality occurred in 1 day. At 0.2 pound per acre, 10 percent toad mortality occurred in 1 day. In a duplicate test there was no mortality at 0.8 pound per acre.	Mulla, et al (1963)
Ronnel	*Penaeus aztecus*	L	–	0.015 (O)	a	Toxicant chemicals were evaluated in sea water at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality.	Butler (1965)
Ronnel	*Leiostomus xanthurus* (juvenile)	BSA	–	0.32 (O)	a	Water temperature was 13 C. The figure reported is a 48-hr EC_{50}.	Butler (1965)
Ronnel	Oyster	BCF	–	0.17 (O)	a	The value reported is a 96-hr EC_{50} (decreased shell growth).	Butler (1965)
Rosinamine D acetate	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – T Ma – T So – PT (7) Cv – T Gp – T Np – T	Palmer and Maloney (1955)
Rosinamine D acetate	*Pimephales promelas*	BSA	–	0.23 (T4A)	a c d e f	Toxicity to 30 species of algae also presented. RADA was algicidal in the range 0.25 to 2.0 ppm.	Maloney and Palmer (1956)
Rosinamine D sulphate	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – T Ma – T So – T (14), PT (21) Cv – T Gp – T Np – T	Palmer and Maloney (1955)
Rosinamine D sulphate (RADS)	*Pimephales promelas*	BSA	–	0.16 (T4A)	a c d e f	Toxicity to 30 species of algae also presented. RADS was algicidal in the range 0.25 to 2.0 ppm.	Maloney and Palmer (1956)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Rosinamine D	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 24th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – T Ma – T So – T (3), PT (14) Cv – T Gp – T Np – T	Palmer and Maloney (1955)
Rosinamine D pentachlorophenate	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Comment same as above except that: Cl – P (7), PT (14) Ma – PT (14) So – NT Cv – T (7), PT (14) Gp – NT Np – T	Palmer and Maloney (1955)
Rosinamine derivative	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Comment same as above except that: Cl – PT Ma – PT (14) So – PT Cv – PT (3) Gp – T Np – T	Palmer and Maloney (1955)
Rotenone (derris or cube with 5% rotenone)	*Salvelinus fontinalis* (yearling)	FL	4 lakes, Nova Scotia	0.20 (K)	a c d f	The work was undertaken to test the feasibility of utilizing poisons as a direct means of studying the production of fish in streams and lakes. Caution must be used to prevent irreparable damage by indiscriminate poisoning.	Smith (1939)
	Couesius plumbeus			0.20 (K)			
	Catostomus commersonnii			0.20 (K)			
	Eels			0.25 (K)			
	Pungitius pungitius			0.25 (K)			
	Micropterus dolomieu			0.25 (K)			

	Morcne americana			0.25 (K)			
Rotenone	*Carassius auratus*	BSA	–	0.100-2.00 (K 8 hr) 0.0600 (O) 0.0400 (T 8 hr) 0.0200 (O)	a	Temperature in test containers was maintained at 27 ± 0.2 C. Goldfish tested weighed between 2 and 4 g. Rotenone, 0.0600 mg per liter, killed 86% of the fish in 8 hr; 0.0200 mg per liter killed 18% in 8 hr.	Gersdorff and Smith (1940)
Rotenone	*Perca flavescens*	BSA	–	0.45 (K)	a c d e p	A range of concentrations between 0.05 and 0.8 ppm was used in this study and kill occurred in 1 to 4 hr.	Burdick, et al (1956)
	Brown trout			0.20 (K)			
	Rock bass			0.32 (K)			
	Creek chub			0.35 (K)			
	Smallmouth bass			0.40 (K)			
	Common sucker			1.7 (K)			
	Brown bullhead			2.2 (K)			
Rotenone (5% cube)	Channel catfish (fingerlings)	BSA	–	0.51 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Rotenone	*Chironomus plumosus* (larvae)	BSA FLA	– Lake Erken, Sweden	(O) (O)	a c	Laboratory studies were with and without silt. Without silt 100% kill occurred in 0.3 ppm rotenone, while 50% kill occurred at 3.0 ppm with silt present. Further data were obtained from field studies and from caged animal studies at various depths and sections of the lake. Data on more than 200 species are presented at 0.5 ppm rotenone lake-bottom-dwelling organisms exhibit sensitivity. Use of higher concentrations than this would mean partial or complete disappearance of many species.	Lindgren (1960)
Rotenone (2.5 percent, 5 percent cube extractives, and 2.5 percent sulfoxide)	*Pimephales promelas*	BSA	–	0.066 (T4A)	a c d f g	Test water was spring water diluted with distilled water. Removal of toxic chemicals by carbon adsorption, chlorine and chlorine dioxide treatment, and alum coagulation was studied. The most effective method to remove fish poisons was by use of activated charcoal adsorption.	Cohen, et al (1961)
Rotenone (5 percent and 15 percent toxaphene)	*Pimephales promelas*	BSA	–	0.066 (T4A)	a c d f g	Comment same as above.	Cohen, et al (1961)
Rotenone (2.0 percent and 7.0 percent toxaphene)	*Pimephales promelas*	BSA	–	0.10 (T4A)	a c d f g	Comment same as above.	Cohen, et al (1961)
Rotenone (5 percent and 10 percent other extractives	*Pimephales promelas*	BSA	–	0.10 (T4A)	a c d f g	Comment same as above.	Cohen, et al (1961)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Rotenone	*Pimephales promelas*	BSA	–	0.006 (T4A)	a c d f g	Test water was spring water diluted with distilled water. Removal of toxic chemicals by carbon adsorption, chlorine and chlorine dioxide treatment, and alum coagulation was studied. The most effective method to remove fish poisons was by use of activated charcoal adsorption.	Cohen, et al (1961)
Rotenone	Entomostraca *Cyclops* *Diaptomus* *Ceriodaphnia* *Bosmina* *Leptodora* Rotaria *Filinia* *Keratella* *Polyarthra* *Asplanchna* *Brachionus* Protozoa *Ceratium* *Difflugia*	FL	Col.	1.0 (K)	a c d g p	All chemical and physical data were collected and compiled by standard limnological techniques. Chemical analyses were conducted monthly. Biweekly plankton collection showed "reduction to zero" of all organisms studied, but recovery of populations to normal population numbers within several months.	Hoffman and Olive (1961)
Rotenone (2.5 percent)	Fish	FL	Mont.	0.95 (O)	a c d e l	Ponds were treated with the chemical to eradicate fish. The fish population included largemouth bass, bluegills, black crappie, yellow perch, carp, white sucker, and longnose sucker. Counts were made of various fish at various later times. The paper contains little quantitative data.	Wollitz (1963)
Rotenone (5.5 percent, cube extract 11.00 percent)	Fish	FL	Mont.	0.7 (O)	a c d e l	Comment same as above.	Wollitz (1963)
Rotenone	Zooplankton	FL	Fern Lake	0.5 (O)	a c d e f	Rotenone (5%) was applied at the rate of 0.5 ppm. Samples were taken biweekly. Open water species were completely removed, and remained absent for 3 mo. Organisms along the shore edge resisted the effect of rotenone, but eventually disappeared for several weeks.	Kiser, et al (1963)
			Silver Lake	1.0 (O)		Rotenone (5%) was applied at the rate of 1.0 ppm. After application the greatest reduction, about 70%, occurred within an hour. Two days after application, no zooplankton were found alive in the open-water tows taken at all depths in the lake. The rotenone penetrated to the thermocline at the 30-ft depth in the first 6 hr, killing *Cladocera* and *Copepoda* as it sank.	
Rotenone	*Gammarus lacustris*	BSA	–	3.52 (T4A)	a e	Emulsible concentrates were prepared from technical grade insecticides with acetone as the solvent. Symptoms prior to death were observed and recorded on graphs.	Nebeker and Gaufin (1964)

Rotenone	*Nereis limnicola*	FL	Lake Merced, Cal.	0.025 (K)	–	In a fish killing program, 0.025 ppm of rotenone was used on October 26, 1963. By November 18 the population of the nereid had been reduced from 500/m^2 to no greater than 10/m^2. How important this organism is in the complex food chain is unknown.	Oglesby (1964)
Rotenone	*Salmo gairdnerii*	BSA	–	27 (T4A)	a c d	Toxicity values reported as median lethal concentration (LC$_{50}$) for 24, 48, and 36 hr.	Bridges and Cope (1965)
	Ictalurus punctatus			28 (T4A)			
	Lepomis macrochirus			23 (T4A)			
	Pteronarcys californica			250 (T4A)			
Rotenone	*Pteronarcys* sp (nymphs)	BSA	–	0.250 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC$_{50}$.	Cope (1965)
Rotenone	*Anax* *Agrion* *Siphlonurus* *Phryganea*	BSA	–	2.3 (T2A)	a c c f,	Death caused by rotenone is caused by the constriction of the gill capillaries which prevent the passage of blood through the gills.	Claffey and Ruck (1967)
Rotenone	*Simocephalus serrulatus*	BSA	–	0.190 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 48 hr. Data cited are for 60 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
	Daphnia pulex			0.100 (SB)			
Rotenone	*Pteronarcys californica* (naiads)	BSA	–	0.38 (T4A)	a c d e f	Data reported as LC$_{50}$ at 15.5 C in 4 days.	Sanders and Cope (1968)
Ruelene	*Salmo gairdneri*	BSA	–	32.0 (T2A)	f	Variance and the 95 percent confidence interval (C.I.) were also determined.	Willford (1966)
	Salmo trutta			25.7 (T2A)			
	Salvelinus fontinalis			35.0 (T2A)			
	Salvelinus namaycush			27.0 (T2A)			
	Ictalurus punctatus			34.8 (T2A)			
	Lepomis macrochirus			35.0 (T2A)			
Ryania (Ryanicide 100)	*Cyprinus carpio*	BSA	–	(O)	a c e	0 percent mortality occurred in 4 days at 0.01 ppm. 0 percent mortality occurred in 4 days at 3 ppm.	Hayes (1955)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Saponin	Shrimp: *Caridina denticulata* *Penaeus carinadus* Fish: *Elops saurus* *Tilapia mossambica*	BSA & FL	Taiwan	50.0 (K1) 70.0 (K1) 1.0 (K1) 1.5 (K)	a	Saponin derived from *Camellia* spp selectively killed fish in bioassays at the concentrations noted while 50-70X higher concentrations were required to kill shrimp. Concentrations of saponin ranging from 2.5-10.0 ppm were similarly effective in pond studies in killing wild fish which prey on or compete with shrimp. This appears to be a good treatment in shrimp culture for shrimp predator control, but the authors caution that further investigation is required.	Tang (1961)
Sarin	*Pimephales promelas* *Lepomis cyanellus* *Carassius auratus*	BCFA	–	10-40 (O)	a c d e	The time for 50 percent (T_{50}) of the fish to die was studied when the toxic material was held constant while dissolved oxygen, temperature and size of fish were varied. Toxic concentrations of sarin were between 10 ppb and 40 ppb oxygen consumption rates are also reported.	Weiss and Botts (1957)
Sarin	*Pimephales promelas* *Lepomis cyananellus* *Carassius auratus*	BSA	–	0.1 to 50.0 (O)	a c d	Data are presented as TL_m/degree centigrade with some of the results as follows: 50 ppm at 24 C was lethal in 0.8 minutes and at 1.20 C in 1.3 minutes for fathead minnows. 50 ppm at 24 C was lethal to sunfish in 0.95 minutes, and at 12 C in 1.55 minutes. 50 ppm at 24 was lethal to goldfish 1.5 minutes, and at 12 C, 2.3 minutes. The toxicity of Sarin was shown to be very temperature dependent. Considerable additional data are presented.	Weiss and Botts (1957)
Sarin	*Lepomis macrochirus* *Lepomis cyanellus* *Pimephales promelas* *Lebistes reticulatus* *Carassius auratus*	BSA + BCFA	–	(S) 3.2 (T4A) (H) 23.5 (T4A) (S) 4.2 (T4A) (H) 15.2 (T4A) (S) 4.4 (T4A) (H) 31.9 (T4A) (S) 1.4 (T4CF) (H) 4.2 (T4CF) (S) 7.2 (T4A) (H) 13.8 (T4A) (S) 9.8 (T4A) (S) 4.1 (T4CF)	a c d e	Both static and continuous flow bioassays were made in hard (H) and soft (S) waters. 24, 48, and 96-hr TM_L are reported. Sarin was more toxic in hard water.	Pickering and Henderson (1959)
Sarin	*Pimephales promelas*	BCFA	–	18 ppb (T 2 hr A)	a c e f	Describes a continuous flow method for bioassay of an organophosphorus CW agent.	Henderson and Pickering (1963)
Schadran	Channel catfish (fingerlings)	BSA	–	>8913 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
SD-4294 (EC32)	*Gambusia affinis*	FL	Ponds in Ill.	(O)	–	When applied at 0.2 pounds per acre active ingredient, 4 percent mortality occurred in 1 day.	Mulla, et al (1963)
SD-4402 (15 percent EC)	*Gambusia affinis*	FL	Ponds – Bakersfield, Cal.	0.1 (K1) 0.4 (K1)	a c	Toxicity values indicate application rates in lb/acre. The experiments were conducted in cages placed in the ponds.	Mulla and Isaak (1961)

SD-7587 (EC2)	*Gambusia affinis*	FL	Ponds in Ill.	(O)	–	When applied at 0.40 pounds per acre active ingredient, 32 percent mortality occurred in 1 day.	Mulla, et al (1963)
SD-8803 (EC2)	*Gambusia affinis*	FL	Cal.	0.4 (K1)	–	Toxicity value is in lb/acre.	Mulla (1966)
SD-9020 (EC2)	*Gambusia affinis*	FL	Cal.	(O)	–	At a concentration of 0.4 lb/acre, 56% mortality of *Gambusia affinis* occurred in 24 hours.	Mulla (1966)
SD-9129 (EC3)	*Gambusia affinis*	FL	Cal.	(O)	–	At a concentration of 0.8 lb/acre, 16% mortality of the fish occurred in 24 hours.	Mulla (1966)
Separan (poly-acrylamide)	Rainbow trout	BSCH	–	(O)	a	A concentration of 0.035 and 0.070 ppm of "Separan" for 4 months caused no rainbow trout mortality. No growth retardation was evident in the lot exposed to 0.035 ppm, and only slight retardation occurred at 0.070 ppm.	Olsen and Foster (1958)
Sernyl	*Carassius auratus*	BSA	–	36 (T 1.5 hr)	a	Fish reacted sluggishly and remained stationary at all concentrations evaluated. Median tolerance limits, median lethal concentrations, and the relation of dosage to time were calculated.	Wilber (1965)
Servin	*Leiostomus xanthurus*	BCFCH	–	0.1 (SB 90)	a	The toxicity of this chemical to fish was relatively low.	Butler and Johnson (1967)
Sevin (50%, and Sevin-tech)	*Carassius auratus*	BSA	–	25 (K2) 14 (L2) 35 (K2) 28 (L2)	a b	The wettable powder formulation (50% Sevin) was prepared on the basis of active ingredient, and stirred directly into water. As a comparison, results were given for Sevin (technical). The wettable powder appeared to be twice as toxic as the Sevin alone under the conditions of this test.	Haynes, et al (1958)
Sevin	*Pimephales promelas* *Lepomis macrochirus*	BSA	–	12.0 (T4A) 5.3 (T4A)	a d e f	Concentrations were based on percent active ingredient.	Henderson, et al (1960)
Sevin	*Pimephales promelas* *Lepomis macrochirus*	BSA	–	12.0 (T4A) 5.3 (T4A)	a	Bioassay investigations of the new insecticides indicate that in general the organic phosphorus compounds are not as toxic to fish as are the chlorinated hydrocarbons. The toxicity of most of these materials was not significantly influenced by water quality. Therefore it is to be expected that the toxicity of these materials will not differ significantly in different streams.	Tarzwell (1959)
Sevin	Ephemeroptera Plecoptera Coleoptera Trichoptera Diptera Annelida Megaloptera	FR	Oneonta, N. Y.	(O)	–	This chemical was highly toxic to mayflies, stoneflies, and caddieflies at 1/4 lb/acre. The fish food populations of invertebrates in the sprayed sections of the streams were reduced from 50.7 to 97.2 percent.	Burdick, et al (1960)
Sevin	*Oncorhynchus kisutch* *Salmo gairdnerii* *Gasterosteus aculeatus*	BSA	–	997 (T4A) 1,350 (T4A) 3,990 (T4A)	a c d e	Chemical dissolved in acetone. TL_m expressed in ppb.	Katz (1961)

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Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Sevin	*Protococcus* sp *Chlorella* sp *Dunaliella euchlora* *Phaeodactylum tricornutum* *Monochrysis lutheri*	BSA	–	10 (NG) 10 (K) 10 (NG) 0.1 (NG) 10 (K) 1.0 (NG)	a	This paper concerns the growth of pure cultures of marine plankton in the presence of toxicants. Results were expressed as the ratio of optical density of growth in the presence of toxicants to optical density in the basal medium with no added toxicants. NG = no growth, but the organisms were viable.	Ukeles (1962)
Sevin (tech)	*Procambarus clarki*	BSA	–	2.0 (T3A)	a c d o	There was no detectable difference in toxicity to male or female crawfish.	Muncy and Oliver (1963)
Sevin (tech)	*Salmo gairdneri*	BSA	–	3,500 (T1A) 2,000 (T2A)	a	The experiment was conducted at 55 F. Fish were 2-3 in. long.	Cope (1963)
Sevin	Aquatic insects: Ephemeroptera Plecoptera *Ameletus* *Iron* *Heptagenia* *Brachyptera* *Alloperla* *Ephemerella* *Simulium*	FR	Pa.	(O)	–	Insecticide spraying dosage was 1.1 kg/4.21 H_2O/hectare, covering over 16,000 acres of woodland for control of gypsy moth. It appeared that there was a drastic reduction of the standing crop of aquatic insects as a result of spraying despite precautions taken against direct spraying of open water and washing spray equipment in the streams.	Coutant (1964)
Sevin	*Pteronarcys* sp (nymphs)	BSA	–	0.0048 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Sevin (tech)	Bluegill	BSA	–	2.0 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
Sevin (carbaryl)	Brown trout (fingerlings)	BSCFA	–	8.0 (K) 15 to 273 minutes	a c e	No significant different in toxicity was found between flow-through and static evaluations. A wide range of concentrations was studied in both hard and soft waters, and a range of sizes of fish were used. The data is given considerable mathematical treatment. The form in which the chemical is used was shown to be important.	Burdick, et al (1965)
Sevin	*Simocephalus serrulatus* *Daphnia pulex*	BSA	–	0.0076 (SB) 0.0064 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 48 hr. Data cited are for 60 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
Sevin (20% active)	*Tubifex* spp *Limnodrilus* spp	BSA	–	750 (L4A)	a c e	Toxicity is reported as the mean lethal dose (LD_{50}) for 24, 48, and 96 hours.	Whitten and Goodnight (1966)

Sevin (Carbaryl)	*Salmo gairdneri*	BSA	–	2.000 (T2A)	a	This paper reports acute toxicity of a number of compounds, and discusses subacute mortality as well. Effects on reproduction and behavior are also discussed. Data presented as EC_{50}.	Cope (1966)
	Lepomis macrochirus			2.500 (T2A)			
	Ictalurus punctatus			19.000 (T2A)			
	Pteronarcys californicus			0.015 (T2A)			
	Daphnia pulex			0.006 (T2A)			
	Simocephalus serrulatus			0.008 (T2A)			
Shell 4072	*Leiostomus xanthurus* (juvenile)	BSA	–	(O)	a	Water temperature was 14 C. Fish lost equilibrium at 1.0 ppm.	Butler (1965)
Shell 4072	Oyster	BCF	–	0.60 (O)	a	The value reported is a 96-hr EC_{50} (decreased shell growth).	Butler (1965)
Shell SD-7438 (tech)	Rainbow trout	BSA	–	0.030 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
	Bluegill			0.250 (T4A)			
Shell SD-7438	*Penaeus aztecus*	L	–	0.028 (O)	a	Toxicant chemicals were evaluated in seawater at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality.	Butler (1965)
Shell SD-7438	Oyster	BCF	–	0.10 (O)	a	The value reported is a 96-hr EC_{50} (decreased shell growth).	Butler (1965)
Shell SD-7961	*Crassostrea virginica*	BCFA & BSA	–	1.0 (NTE)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
	Penaeus setiferus			1.0 (NTE)			
	Leiostomus xanthurus			1.0 (NTE)			
	Phytoplankton			(O)			
Shell SD-7961	Oyster	BCF	–	(O)	a	No effect on exposure to the chemical at 1.0 ppm.	Butler (1965)
Shell SD-7961	*Leiostomus xanthurus* (juvenile)	BSA	–	(O)	a	Water temperature was 16 C. No effect was noticed on exposure to 1.0 ppm.	Butler (1965)
Shell SD-8447	*Leiostomus xanthurus* (juvenile)	BSA	–	(O)	a	Water temperature was 17 C. Fish showed irritation at 1.0 ppm.	Butler (1965)
	Oyster	BCF	–	(O)	a	No effect on exposure to the chemical at 1.0 ppm.	Butler (1965)
	Penaeus duorarum	L	–	0.42 (O)	a	Toxicant chemicals were evaluated in sea water at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality.	Butler (1965)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Shell SD-8448	*Penaeus duorarum*	L	–	0.28 (O)	a	Toxicant chemicals were evaluated in seawater at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality.	Butler (1965)
Shell SD-8448	Oyster *Leiostomus xanthurus* (juvenile)	BCF BSA	–	0.40 (O) (O)	a	The value reported is a 96-hr EC_{50} (decreased shell growth). Water temperature was 19 C. Lost equilibrium at 1 ppm.	Butler (1965)
Shell SD-9129, EC	Rainbow trout Bluegill	BSA	–	4.90 (T4A) 4.0 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
Shell SD-9129	Oyster *Fundulus similis* (juvenile)	BCF BSA	– –	(O) (O)	a a	No effect on exposure to the chemical at 1.0 ppm. Water temperature was 20 C. No effect was noticed on exposure to 1.0 ppm.	Butler (1965)
	Penaeus aztecus	L	–	0.32 (O)	a	Toxicant chemicals were evaluated in seawater at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality.	Butler (1965)
Silvex	Aquatic weeds in Georgia including *Najas* sp *Potamogeton* sp *Myriophyllum heterophyllum* *Utricularia* sp *Myriophyllum brasiliense* *Eleocharis acicularis*	FL	Farm ponds in Ga.	(O)	–	Silvex in concentrations of 0.2 to 3.0 ppm killed 75 to 100 percent of the most prominent and damaging weeds. A slow kill is desirable because there is less chance of a fish kill due to an oxygen depletion resulting from weed decomposition. The results of 2 years' experimentation on control of aquatic weeds in Georgia farm ponds using Silvex indicated that this herbicide has a far wider range of satisfactory control than any other herbicide used in Georgia.	Thomaston, et al (1959)
Silvex	Bluegill	FP	Okla.	1.5 to 3.0 (O)	–	This paper concerns lack of growth in weight and length of fish. A coefficient of condition C(TL) was derived from fish lengths in inches and weights in grams, and is expressed as a ratio of 100,000 x weight in pounds to the cube of the length in inches. The C(TL) of the fish is reported to be a result of the application of the herbicide over a 2-year period.	Houser (1962)
Silvex (Amchem)	*Lepomis macrochirus*	BSA	–	700 (T 18 hr) 600 (T 32 hr)	a	The experiment was conducted at 65 F. Fish were 2 in. long.	Cope (1963)
Silvex (K salt)	*Lepomis macrochirus*	BSA	–	83.0 (T2A) L 100.0 (T2A) G	a c d e g	Toxicity data for 24 and 48 hours are presented for liquid (L) and granular (G) formulations. Various commercial formulations were tested. The liquid formulations were almost invariably more toxic than the granular ones.	Hughes and Davis (1965)

Silvex	Filamentous algae	FL	N. Y.		a c		Cowell (1965)
	Cladophora			(O)		2 ppm caused 20% kill.	
	Spirogyra			(O)		2 ppm caused 35% kill.	
	Hydrodictyon			2.0 (K)			
	Submerged plants						
	Chara			(O)		2 ppm did not cause any kill.	
	Potamogeton			2.0 (K)		Complete decomposition occurred in about 3 weeks.	
	Emergent plants						
	Alisma			(O)		2 ppm did not cause any kill.	
	Sagittaria			(O)		2 ppm caused 20% kill.	
	Floating plants						
	Lemna			2.0 (K)		Complete decomposition occurred in about 3 weeks.	
	Zooplankton			(O)		Applications of 4 ppm produced significant reduction.	
Silvex (Kuron)	*Lepomis macrochirus*	BSA	–	2.4 (T4A)	a c e	Bioassay method in Standard Methods for Examination of Water was used. TL_m values for 24 and 48 hr are also presented.	Surber and Pickering (1962)
	Pimephales promelas			7.2 (T4A)			
Silvex (pelletized)	*Lepomis macrochirus*	BSA	–	(S) 14 (T4A) (H) 86 (T4A)	a c e	Comment same as above.	Surber and Pickering (1962)
	Pimephales promelas			(S) 13 (T4A) (H) 73 (T4A)			
Silvex (butoxyethanol ester)	*Lepomis macrochirus*	BSA	–	1.2 (T2A)	a e	The various salts of the chemicals showed wide variations in toxicity.	Hughes and Davis (1963)
Silvex (isooctyl ester)	*Lepomis macrochirus*	BSA	–	3.7 (T2A)	a e	Comment same as above.	Hughes and Davis (1963)
Silvex (potassium salt)	*Lepomis macrochirus*	BSA	–	8.3 (T2A)	a e	Comment same as above.	Hughes and Davis (1963)
Silvex (propylene glycol butylether ester)	*Lepomis macrochirus*	BSA	–	16.6 (T2A)	a e	Comment same as above.	Hughes and Davis (1963)
Silvex	Benthic community of a farm pond	FL	Boone County, Mo.	2.8 & 4.6 (O)	c d	Many different aquatic plants, insects, molluscs, and leeches are listed, 79 organisms in all. Data list populations in treated versus untreated pond areas as well as seasonal variations in numbers. The tests were conducted in a series of plastic enclosures 12 x 18 feet in area, and 4 feet deep. The most conspicuous change in the pond benthos in the enclosures treated with silvex was numerical increase at both treatment concentrations. Tendipedids, oligochaetes, *Chaoborus*, and libelludids, increased markedly. The densities of damsel flies, leeches, and snails, were unaffected. *Chrysops* alone decreased. Other groups of organisms were not sufficiently numerous for analysis. The increases may have been caused by the enriching influence of decaying vegetation. The application rate of 2.8 ppm was within the recommended range of concentrations while 4.6 ppm was in excess of recommended rates.	Harp and Campbell (1964)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Silvex (triethyl-amine)	*Lepomis macrochirus*	BSA	–	20 (T1A)	a b e	This report is a simple and straightforward determination of a median tolerance limit for a selected group of herbicides.	Hughes and Davis (1967)
Silvex (triethyl-amine)	*Lepomis macrochirus*	BSA	–	16 (T1A)	a b e	Comment same as above.	Hughes and Davis (1967)
Silvex (polyglycol butyl ether ester)	*Penaeus aztecus*	L	–	0.28 (O)	a	Toxicant chemicals were evaluated in seawater at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality.	Butler (1965)
Silvex	*Leiostomus xanthurus* (juvenile)	BSA	–	0.36 (O)	a	Water temperature was 16 C. The figure reported is a 48-hr EC_{50}.	Butler (1965)
Silvex (polyglycol butyl ether ester)	*Crassostrea virginica* *Penaeus aztecus* *Leiostomus xanthurus* Phytoplankton	BCFA & BSA	–	1.0 (O, 20%) 0.24 (O) 0.36 (T2CFA) 78% (O)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
Silvex	*Salmo gairdneri* *Lepomis macrochirus* *Pteronarcys californicus* *Daphnia pulex* *Simocephalus serrulatus*	BSA	–	1.4 (T2A) 16.6 (T2A) 0.76 (T2A) 2.40 (T2A) 2.0 (T2A)	a	This paper reports acute toxicity of a number of compounds, and discusses subacute mortality as well. Effects on reproduction and behavior are also discussed. Data presented as EC_{50}.	Cope (1966)
Silvex (K salt)	*Daphnia magna* Rainbow trout Bluegill	BSA	–	100 (O) 21.9 (O) 14.5 (O)	a c d i q	Toxicity, in terms of median immobilization concentration (IC_{50}), is presented for *Daphnia*; median lethal concentration (LC_{50}) for rainbow trout and bluegill are reported.	Crosby and Tucker (1966)
Silvex	Salmon Bluegill	BSA	–	1.23 (T2A) 0.60 (T2A)	--	Data are given as LC_{50}.	Bohmont (1967)

Silvex (potassium salt)	*Lepomis macrochirus* (eggs) *L. cyanellus* (eggs) *Micropterus dolomieui* (eggs) *Erimyzon sucetta* (eggs) *L. macrochirus* (fry)	BSA	–	20 (NTE) 20 (NTE) 20 (NTE) 50 (S)	–	Fertilized fish eggs of indicated species were placed in 1 liter of test solution and allowed to hatch. Toxicity data are presented as concentration in ppm/number of days survival. Maximum length of test was 8 days. No food was added. Small bluegill were tested to find the highest concentration of chemical which did not cause death in 12 days (S).	Hiltibran (1967)
Silvex (ester)	*Lepomis macrochirus* (eggs) *L. cyanellus* (eggs) *L. macrochirus* (fry)	BSA	–	10 (NTE) 10 (NTE) 20 (S)	–	Comment same as above.	Hiltibran (1967)
Silvex (ester)	*Lepomis macrochirus* (eggs) *L. cyanellus* (eggs) *Micropterus dolomieui* *Erimyzon sucetta* *L. macrochirus* (fry)	L	–	2.4/2 (O) 1.0 (NTE) 2.4/4 (O) 1.0/4 (O) 2.4 (NTE) 1.0 (NTE) 2.0 (S)	–	Comment same as above.	Hiltibran (1967)
Silvex (potassium salt)	*Lepomis macrochirus* *L. cyanellus*	BSA	–	30 (S) 10 (NTE)	–	Comment same as above.	Hiltibran (1967)
Silvex (sodium salt)	*Lepomis macrochirus* (fry)	BSA	–	50 (S)	–	Comment same as above.	Hiltibran (1967)
Silvex	*Pteronarcys californica* (naiads)	BSA	–	0.00034 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Simazen (granular)	*Althernanthera philoxeroides*	FL	Fla.	(O)	–	At 10.0 lb/acre, alligator weed was not affected.	Copeland and Woods (1959)
Simazine	*Nymphaea* sp *Leersia* sp *Paspalum* sp *Juncus* sp	FL	Farm ponds in Ga.	(O)	–	Although *Nymphaea* sp was killed at a rate of 50 lb/acre, no epinastic effects were noted. The chemical did not translocate and only killed the tops. Treatments on *Leersia* sp, *Paspalum* sp, and *Juncus* sp were unsuccessful and gave no encouraging results. Limited use of simazine has not proven it to be a satisfactory aquatic herbicide in Georgia.	Thomaston, et al (1959)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Simazine	*Onchorynchus tshawytscha*	BSA & CF	–	7.0 (T1A) 6.6 (T2A)	a c d e	Concentrations were based on percent active ingredient. Median tolerance limits for 72 and 96 hours estimated from the constant flow experiment were 7.2 ppm and 6.5 ppm, respectively, for this species.	Bond, et al (1960)
Simazine (herboxy-1962)	*Phoxinus phoxinus*	BSA	–	(O)	a c d e	Two series of aquarium aerated tests were performed, one without plants (*Callitriche*, and *Elodea*). 20% kill occurred in 3 days. The highest nonlethal concentration was 5 ppm.	Vivier and Nisbet (1965)
Simazine (herboxy-1960)	*Phoxinus phoxinus*	BSA	–	1.25 (K2A) 1.5 (T2A)	a c d e	Two series of aquarium tests were performed, with and without plants, which lowered the toxicity. 90% kill occurred at 5 ppm in 6 hr.	Vivier and Nisbet (1965)
Simazine	*Micropterus salmoides* (fry)	BSA	–	25.0 (SB3)	a c d e f p	At least 90 percent of the fry survived for a period of 72 hours at the concentration listed.	Jones (1965)
	Ictalurus punctatus (fry)			10.0 (SB3)			
	Lepomis macrochirus (fry)			10.0 (SB3)			
Simazine	Phytoplankton	FL	Ala.	2.0 (K1)	a	In a series of bass spawnings and rearing ponds, Simazine was used at concentrations of 0.5, 1.0, and 2.0 ppm to control light to medium growths of phytoplankton which interferred with bass production. Success was uniform with control lasting for as long as 85 days. No fish kills occurred and the chemical was apparently not toxic to zooplankton.	Snow (1963)
	Hydrodictyon reticulatum						
	Zygnema spp etc.			2.0 K1)			
	Zooplankton			(O)			
	Fish						
	Micropterus salmoides			(O)			
	Lepomis cyanellus			(O)			
Simazine (WP)	Bluegill	BSA	–	118 (T4A)	a	This is an estimated LC_{50} value at temperatures from 55 to 75 F.	Cope (1965)
	Rainbow trout			56 (T4A)			
Simazine (WP)	*Lepomis macrochirus* (eggs)	L	–	10/4 (O)	–	Fertilized fish eggs of indicated species were placed in 1 liter of test solution and allowed to hatch. Toxicity data are presented as concentration in ppm/number of days survival. Maximum length of test was 8 days. No food was added. Small bluegill were tested to find the highest concentration of chemical which did not cause death in 12 days (S).	Hiltibran (1967)
	L. cyanellus (eggs)			10/5 (O)			
	Micropterus dolomieui (eggs)			10/3 (O)			
	Erimyzon sucetta (eggs)			10 (NTE)			
	L. macrochirus (fry)			0.3 (S)			

Simazine	Rainbow trout	BSA	–	56.0 (T2A)	–	Data are given as LC_{50}.	Bohmont (1967)
	Bluegill			118.0 (T2A)			
Simazine	*Lepomis macrochirus* (eggs)	L	–	10 (NTE)	–	Fertilized fish eggs of indicated species were placed in 1 liter of test solution and allowed to hatch. Toxicity data are presented as concentration in ppm/number of days survival. Maximum length of test was 8 days. No food was added. Small bluegill were tested to find the highest concentration of chemical which did not cause death in 12 days (S).	Hiltibran (1967)
	L. cyanellus (eggs)			10/7 (O)			
	Micropterus dolomieui (eggs)			10 (NTE)			
	Erimyzon sucetta (eggs)			10 (NTE)			
				10 (S)			
Sinox	*Richardsonius balteatus hydroflox*	BSA	–	0.16 (T1A) 0.14 (T2A) 0.13 (T4A)	a c d e f	Results given were in soft water. Results in hard water were as follows: 0.24 (T1A), 0.24 (T2A), and 0.24 (T4A).	Webb (1961)
Slickgone 1	*Pandalus montagni*	BSA	–	5.2 (T2A)	a e	Experiments were conducted in tanks holding 10 liters of seawater at 15 C. It was shown that the toxicity of this solvent emulsifier decreased with time due to evaporation of the solvent.	Portmann and Connor (1968)
	Crangon crangon			6.6 (T2A)			
	Cardium edule			32.4 (T2A)			
	Carcinus malmas			35.0 (T2A)			
Slickgone 2	*Pandalus montagni*	BSA	–	4.5 (T2A)	a e	Comment same as above.	Portmann and Connor (1968)
	Crangon crangon			3.5 (T2A)			
	Cardium edule			30.5 (T2A)			
	Carcinus maenas			21.3 (T2A)			
Slix	*Pandalus montagni*	BSA	–	12.1 (T2A)	a e	Experiments were conducted in tanks holding 10 liters of seawater at 15 C. It was shown that the toxicity of this solvent emulsifier decreased with time due to evaporation of the solvent. Slix at a concentration of 10 ppm killed 100% of *Crangon crangon* larvae in 3 hr; at 33.3 ppm it killed 70% of *Carcinus maenas* larvae in 3 hr.	Portmann and Connor (1968)
	Crangon crangon			114.5 (T2A)			
	Carcinus maenas			150.0 (T2A)			
	Cardium edule			12.7 (T2A)			
Soaps (household)	*Pimephales promelas* (juveniles)	BSA	–	(S) 34-39 (T1-4A) (H) 1,470-1,530 (T1-4A)	a c d f	Syndets and soaps were of nearly equal toxicity in soft water (S) but syndets were approximately 40X more toxic than soap in hard water (H).	Henderson, et al (1960)
Sovicide tetra aminol	*Phoxinus phoxinus*	BSA	–	8 (100%K)	a c d e	The highest concentration nonlethal in 6 hr was 4 ppm.	Vivier and Nisbet (1965)
Stam F-34, tech.	*Salmo gairdnerii*	BSA	–	4,000 (T2A)	a	The experiment was conducted at 55 F. Fish were 2-3 in. long.	Cope (1963)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Stauffer N2790	*Leiostomus xanthurus* (juvenile)	BSA	–	0.24 (O)	a	Water temperature was 24 C. The figure reported is a 48-hr EC_{50}.	Butler (1965)
	Oyster	BCF		0.33 (O)		The value reported is a 96-hr EC_{50} (decreased shell growth).	Butler (1965)
	Penaceus aztecus	L		0.0024 (O)		Toxicant chemicals were evaluated in sea water at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality.	Butler (1965)
Stauffer N-2790 (tech)	Rainbow trout	BSA	–	0.019 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
	Bluegill			0.0062 (T4A)			
Stauffer R-1910	*Penaeus aztecus*	L	–	(O)	a	Toxicant chemicals were evaluated in seawater at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality. No effect occurred at 1.0 ppm.	Butler (1965)
	Leiostomus xanthurus (juvenile)	BSA	–	(O)	a	Water temperature was 25 C. No effect was noticed on exposure to 1.0 ppm.	Butler (1965)
	Oyster	BCF				No effect on exposure to the chemical at 1.0 ppm.	Butler (1965)
Stauffer (R-1910, tech)	Rainbow trout	BSA	–	3.6 (T4A)	a	This is an estimated LC_{50} value at temperatures from 55 to 75 F.	Cope (1965)
	Bluegill			5.5 (T4A)			
Stauffer R-1910	*Crassostrea virginica* *Penaeus setiferus* *Leiostomus xanthurus* *Fundulus similis* *Mugil cephalus* *Cyprinodon variegatus* Phytoplankton	BCFA	–	1.0 (NTE, all species)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
Stauffer R-4461	*Crassostrea virginica*	BCFA & BSA	–	0.45 (O)	–	Comment same as above.	Butler (1965)
	Penaeus aztecus			1.0 (O, 10%)			
	Leiostomus xanthurus			0.32 (T4CFA)			
	Phytoplankton			NTE			
Stauffer R-4461	Oyster	BCF	–	0.45 (O)	a	The value reported is a 96-hr EC_{50} (decreased shell growth).	Butler (1965)

Stauffer R-4461	*Penaeus aztecus*	L	–	(O)	a	Toxicant chemicals were evaluated in seawater at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality. No effect occurred at 1.0 ppm.	Butler (1965)
Stauffer R-4461 (tech)	Rainbow trout	BSA	–	0.72 (T4A)	a	This is an estimated LC_{50} value at temperatures from 55 to 75 F.	Cope (1965)
	Bluegill			0.81 (T4A)			
Stauffer R-4461	*Leiostomus xanthurus* (juvenile)	BSA	–	0.32 (O)	a	Water temperature was 25 C. The figure reported is a 48-hr EC_{50}.	Butler (1965)
Stauffer R-5092	*Leiostomus xanthurus* (juvenile)	BSA	–	0.02 (O)	a	Water temperature was 26 C. The figure reported is a 48-hr EC_{50}.	Butler (1965)
	Oyster	BCF	–	(O)	a	No effect on exposure to the chemical at 1.0 ppm.	Butler (1965)
	Penaeus aztecus	L	–	0.0032 (O)	a	Toxicant chemicals were evaluated in seawater at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality.	Butler (1965)
Steramine	*Chlorella pyrenoidosa*	L	–	20 (AC <1/2	–	Describes a bioassay method to differentiate between an algicide (AC) and an algistat (AS). The treated culture was subcultured as time progressed. Allen's medium was used.	Fitzgerald and Faust (1963)
Streptomycin sulfate	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – T Ma – T So – T Cv – NT Gp – NT Np – T (21)	Palmer and Maloney (1955)
Strobane	Blue crab	FE	Bombay Hook Island, Del.	(O)	–	Strobane was applied at the rate of 0.3 pound per acre. The location under study was a salt marsh bounded by Delaware Bay. Organisms were confined in cages within the test area. *C. variegatus*, *M. curema*, and *L. xanthurus* showed 16 percent mortality in 7 days. Blue crabs showed 27 percent mortality when exposed for 7 days in streams and 20 percent mortality in ponds. Marsh fiddler crabs and red-jointed fiddler crabs showed mortalities of 68 and 20 percent, respectively, when exposed for 7 days.	George, et al (1957)
	Marsh fiddler crab			(O)			
	Red-jointed fiddler crab			(O)			
	Cyprinodon variegatus			(O)			
	Mugil curema			(O)			
	Leiostomus xanthurus			(O)			
Strobane + methyl parathion	Oyster	BCF	–	0.026 (O)	a	The value reported is a 96-hr EC_{50} (decreased shell growth).	Butler (1965)
Strobane	*Pteronarcys* sp (nymphs)	BSA	–	0.0005 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Strobane	Oyster	BCF	–	0.02-0.059 (O)	a	The value reported is a 96-hr EC_{50} (decreased shell growth).	Butler (1965)
Strobane (tech)	Bluegill	BSA	–	0.0084 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
Strobane	*Pteronarcys californica* (naiads)	BSA	–	0.0005 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Sulfotepp	Channel catfish (fingerlings)	BSA	–	<1.0 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1969)
Swep	*Lepomis macrochirus*	BSA	–	6.0 (T1A)	a b e	This report is a simple and straightforward determination of a median tolerance limit for a selected group of herbicides.	Hughes and Davis (1967)
"Synthetic detergent"	Sludge worms	BSA	–	23 (T4A)	a c d i	Data using hard and soft water are presented as well as information on the effect of temperature. Additional TL_m data are presented.	Wurtz and Bridges (1961)
Systox	*Pimephales promelas*	BSA	–	3.9 (T4A)	a c d e f	Tests were performed in both hard and soft water. Additional tolerance limit values are given.	Henderson and Pickering (1958)
Systox	Fathead minnow	BSA	–	4.2 (T4A)	a	It was the authors opinion that pH, alkalinity and hardness, within the usual range in natural waters, had little effect on the toxic effect of the compounds studied. The values given are from Henderson, Pickering, and Tarzwell, "The Relative Toxicity of Ten Chlorinated Hydrocarbon Insecticides to Four Species of Fish". It is interesting that the different tables from the above book (as reported in this paper) report widely different values for the same compounds. This experiment was performed in hard water.	Tarzwell (1959)
Systox	*Pimephales promelas*	BSA	–	3.6 (T4A)	a d e f	Concentrations were based on percent active ingredient.	Henderson, et al (1959)
Systox	*Pimephales promelas*	BSA	–	3.6 (T4A)	a	Bioassay investigations of the new insecticides indicate that in general the organic phosphorus compounds are not as toxic to fish as are the chlorinated hydrocarbons. The toxicity of most of these materials was not significantly influenced by water quality. Therefore it is to be expected that the toxicity of these materials will not differ significantly in different streams.	Tarzwell (1959)
Systox (tech, 92 percent)	*Pimephales promelas*	BSA	–	2.9 (T4A)	a c d e	Soft water primarily was the test medium. TL_m's reported for 24, 48, and 96 hr. Acetone or alcohol used as solvent or carrier in most cases.	Pickering, et al (1962)
	Lepomis macrochirus			0.11 (T4A)			
	Carassius auratus			12 (T4A)			
	Lebistes reticulatus			0.66 (T4A)			

2,4,5-T	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	–	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – NT Ma – T (3) So – NT Cv – NT Gp – NT Np – NT	Palmer and Maloney (1955)
2,4,5-T (pellets)	*Althernanthera philoxeroides* *Najas quadalupensis* Spatterdock	FL	Fla.	(O)	–	The degree of control was as follows: *A. philoxeroides* (20 lb/acre) – 95 percent *N. quadalupensis* (24 lb/acre) – none Spatterdock (21.8 lb/acre) – 3 percent.	Copeland and Woods (1959)
2,4,5-T	*Althernanthera philoxeroides*	FL	Fla.	(O)	–	At 0.5 lb/acre, only 1-2 percent control of alligator weed was obtained.	Copeland and Woods (1959)
2,4,5-T (dimethylamine ester)	*Lepomis macrochirus*	BSA	–	144 (T2A)	a e	The various salts of the chemicals showed wide variations in toxicity.	Hughes and Davis (1963)
2,4,5-T (butoxyethanol ester)	*Lepomis macrochirus*	BSA	–	1.4 (T2A)	a e	Comment same as above.	Hughes and Davis (1963)
2,4,5-T (isooctyl ester)	*Lepomis macrochirus*	BSA	–	26 (T2A)	a e	Comment same as above.	Hughes and Davis (1963)
2,4,5-T (propylene glycol butyl ether ester)	*Lepomis macrochirus*	BSA	–	17 (T2A)	a e	Comment same as above.	Hughes and Davis (1963)
2,4,5-T (oleic-1,3-propylene diamine)	*Lepomis macrochirus*	BSA	–	2.9 (T1A)	–	The bioassay methods employed in this experiment were not given in the paper but it was stated that the same procedures were employed as in previous work.	Davis and Hughes (1963)
2,4,5-T (isopropyl ester)	*Lepomis macrochirus*	BSA	–	1.8 (T1A)	–	Comment same as above.	Davis and Hughes (1963)
2,4,5-T (triethyl amine)	*Lepomis macrochirus*	BSA	–	53.7 (T1A)	–	Comment same as above.	Davis and Hughes (1963)
2,4,5-T	*Lepomis macrochirus*	BSA	–	11.0 (T1A)	a b e	This report is a simple and straightforward determination of a median tolerance limit for a selected group of herbicides.	Hughes and Davis (1967)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
2,4,5-T (polyglycol butyl ether ester)	Oyster	BCF	–	0.14 (O)	a	The value reported is a 96-hr EC_{50} (decreased shell growth).	Butler (1965)
2,4,5-T	*Leiostomus xanthurus* (juvenile)	BSA	–	0.32 (O)	a	Water temperature was 16 C. The figure reported is a 48-hr EC_{50}.	Butler (1965)
2,4,5-T (polyglycol butyl ether ester)	*Penaeus aztecus*	L	–	(O)	a	Toxicant chemicals were evaluated in seawater at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality.	Butler (1965)
2,4,5-T (acid)	*Penaeus aztecus*	L	–	(O)	a	Toxicant chemicals were evaluated in seawater at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality. No effect occurred at 1.0 ppm.	Butler (1935)
2,4,5-T (polyglycol butyl ether ester)	*Crassostrea virginica*	BCFA & BSA	–	0.14 (O)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
	Penaeus aztecus			1.0 (O,20%)			
	Leiostomus xanthurus			0.32 (T2CFA)			
	Phytoplankton			89% (O)			
2,4,5-T (acid)	*Crassotrea virginica*	BCFA & BSA	–	20 (NTE)	–	Comment same as above.	Butler (1965)
	Penaeus aztecus			1.0 (NTE)			
	Mugil caphalus			50.0 (NTE)			
	Phytoplankton			–			
2,4,5-T (polyglycol butyl ether ester	*Crassostrea virginica*	BCFA & BSA	–	0.14 (O)	–	Comment same as above.	Butler (1965)
	Penaeus aztecus			1.0 (O, 20%)			
	Leiostomus xanthurus			0.32 (T2CFA)			
	Phytoplankton			89% (O)			
2,4,5-T (ester)	*Lepomis macrochirus* (eggs)	L	–	10 (NTE)		Fertilized fish eggs of indicated species were placed in 1 liter of test solution and allowed to hatch. Toxicity data are presented as concentration in ppm/number of days survival. Maximum length of test was 8 days. No food was added. Small bluegill were tested to find the highest concentration of chemical which did not cause death in 12 days (S).	Hiltibran (1967)
	L. cyanellus			10 (NTE)			
	L. macrochirus (fry)			10 (S)			

2,4,5-T (ester)	*Lepomis macrochirus*	L	=	1.0 (NTE)	–	Comment same as above.	Hiltibran (1967)
	L. cyanellus			4/1 (O), 1.0 (NTE)			
	Micropterus dolomieui			4/0 (O), 1.0 (NTE)			
	L. macrochirus (fry)			1.0 (S)			
2,4,5-T (sodium salt)	*Lepomis macrochirus* (fry)	L	=	50 (S)	–	Comment same as above.	Hiltibran (1967)
TAG 10%	Channel catfish (fingerlings)	BSA	=	1.5 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
2,3,5-TBA	*Lepomis macrochirus*	BSA	=	90 (T2A)	a c o	The response of bluegill and bass fingerlings to nine agricultural chemicals as determined by bioassay using river water is presented in this report. Bluegills were more tolerant of the chemicals tested than bass.	Davis and Hardcastle (1959)
	Micropterus salmoides			55 (T2A)			
2,3,6-TBA	*Lepomis macrochirus*	BSA	=	1750 (T2A)	a c o	Comment same as above.	Davis and Hardcastle (1959)
	Micropterus salmoides			1250 (T2A)			
TCA 90%	Channel catfish (fingerlings)	BSA	=	>2000 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Sodium TCA	*Onchorynchus tshawytscha*	BSA	=	870 (NTE)	a c d e	Concentrations were based on percent active ingredient.	Bond, et al (1960)
Sodium TCA	*Mugil cephalus* (juvenile)	BSA	=	(O)	a	Water temperature was 28 C. No effect was noticed on exposure to 1.0 ppm.	Butler (1965)
Sodium TCA	*Penaeus aztecus*	L	=	(O)	a	Toxicant chemicals were evaluated in seawater at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality. No effect occurred at 1.0 ppm.	Butler (1965)
TD 47	*Micropterus salmoides* (fry)	BSA	=	0.075 (SB3)	a c d e f p	At least 90 percent of the fry survived for a period of 72 hours at the concentration listed.	Jones (1965)
	Ictalurus punctatus (fry)			0.2 (SB3)			
	Lepomis macrochirus (fry)			0.2 (SB3)			

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
TD-47	Carp-goldfish hybrid	BSA	=	175 (T4A)	a	In addition to the median tolerance limits, this report also has data on the residue of the chemical in the fish, some of the physiological effects, and degradation curves for the chemical in water.	Walker (1963)
	Notropis umbratilis			95 (T4A)			
	N. lutrensis			105 (T4A)			
	Pimephales notatus			120 (T4A)			
	Ictaluris natalis			175 (T4A)			
	I. melas			180 (T4A)			
	Lepomis macrochirus			125 (T4A)			
	L. microlophus			125 (T4A)			
	Micropteris salmoides			120 (T4A)			
TD-72 (EC6)	*Gambusia affinis*	FL	Ponds in Ill.	(O)	–	When applied at 0.5 pounds per acre active ingredient, 18 per-cent mortality occurred in 1 day.	Mulla (1963)
TD-282 [di(N,N-dimethyltri-decylamine) salt of Endothall]	*Australorbis glabratus*	BSA & FL	Puerto Rico	Variable (O)	c	Seven of the tested compounds failed to meet acceptability criteria – that is, complete kill after 6-hr exposure to 10 ppm. They were not used in field tests. Field tests showed WL 8008 to be highly effective.	Seiffer and Schoof (1967)
TD-283 (mono-N,N-dimethyltri-decylamine) salt of Endothall)	*Australorbis glabratus*	BSA & FL	Puerto Rico	3.8-6.2 (O)	c	Comment same as above.	Seiffer and Schoof (1967)
TD-440	*Lepomis macrochirus*	BSA	=	3.0 (T1A)	a b e	This report is a simple and straightforward determination of a median tolerance limit for a selected group of herbicides.	Hughes and Davis (1967)
TD-497	*Lepomis macrochirus*	BSA	=	4.0 (T1A)	a b e	Comment same as above.	Hughes and Davis (1967)
Telodrin	*Leiostomus xanthurus* (juvenile)	BSA	=	0.0003 (O)	a	Water temperature was 13 C. The figure reported is a 48-hr EC_{50}.	Butler (1965)
Telodrin	*Leiostomus xanthurus* (juvenile)	BCH	=	(O)	a	A concentration of 0.000025 ppm will kill in 10 days. The fish were able to survive for 5 months in a concentration of 0.00001 ppm.	Butler (1965)
TEPP	Fish	BSA	=	0.25 (K)	–	A concentration of 0.25 ppm was lethal in aquarium tests.	Linduska and Surber (1948)

TEPP	Fathead minnow	BSA	=	1.0 (T4A)	a	It was the authors opinion that pH, alkalinity and hardness, within the usual range in natural waters, had little effect on the toxic effect of the compounds studied. The values given are from Henderson, Pickering, and Tarzwell, "The Relative Toxicity of Ten Chlorinated Hydrocarbon Insecticides to Four Species of Fish". It is interesting that the different tables from the above book (as reported in the paper) report widely different values for the same compounds. This experiment was performed in hard water.	Tarzwell (1959)
TEPP	*Pimephales promelas* *Lepomis macrochirus*	BSA	=	1.7 (T4A) 0.84 (T4A)	a c d e f	Tests were performed in both hard and soft water. Additional tolerance limit values are given.	Henderson and Pickering (1958)
TEPP	*Pimephales promelas*	BSA	=	1.7 (T4A)	a	Bioassay investigations of the new insecticides indicate that in general the organic phosphorus compounds are not as toxic to fish as are the chlorinated hydrocarbons. The toxicity of most of these materials was not significantly influenced by water quality. Therefore it is to be expected that the toxicity of these materials will not differ significantly in different streams.	Tarzwell (1959)
TEPP	Channel catfish (fingerlings)	BSA	=	2.3 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
TEPP	*Pimephales promelas*	BSA	=	1.7 (T4A)	a d e f	Concentrations were based on percent active ingredient.	Henderson, et al (1960)
TEPP	*Protococcus* sp *Chlorella* sp *Dunaliella* sp *Phaeodactylum tricornutum* *Monochrysis lutheri*	L	=	500 (NG) 500 (NG) 500 (K) 500 (K) 500 (K)	a	This paper concerns the growth of pure cultures of marine plankton in the presence of toxicants. Results were expressed as the ratio of optical density of growth in the presence of toxicants to optical density in the basal medium with no added toxicants. NG = no growth, but the organisms were viable.	Ukeles (1962)
TEPP (tech, 40 percent)	*Pimephales promelas* *Lepomis macrochirus* *Carassius auratus* *Lebistes reticulatus*	BSA	=	2.1 (T4A) 1.3 (T4A) 21 (T4A) 1.8 (T4A)	a c d e	Soft water primarily was the test medium. TL_m's reported for 24, 48, and 96 hr. Acetone or alcohol used as solvent or carrier in most cases.	Pickering, et al (1962)
Terramycin	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	=	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – PT (7) Ma – T So – NT Cv – NT Gp – NT Np – T (3) PT (7)	Palmer and Maloney (1955)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Thanite (isobornyl thiocyano-acetate)	Green sunfish	BSA	—	1.0 (K 6 hr) 0.5 (K 6 hr)	a e p	The main purpose of this experiment was to determine the repellent characteristics of certain chemicals. The experiments were conducted in a wooden trough.	Summerfelt and Lewis (1967)
Tetrachlorophene	*Cylindrospermum licheniforme (Cl)* *Microcystis aeruginosa (Ma)* *Scenedesmus obliquus (So)* *Chlorella variegata (Cv)* *Gomphonema parvulum (Gp)* *Nitzschia palea (Np)*	L	—	2.0 (O)	a	Observations were made on the 3rd, 7th, 14th, and 21st days to give the following (T = toxic, NT = nontoxic, PT = partially toxic with number of days in parentheses. No number indicates observation is for entire test period of 21 days): Cl – T (3) PT (7) Ma – NT So – PT (7) Cv – PT (3) Gp – NT Np – T (3)	Palmer and Maloney (1955)
TFM	*Petromyzon marinus*	BSA	—	3-10 (O)	a c d e	Three types of dilution water used with hardness values of 95.4, 141.7, and 203.3 ppm. As a lamprey larvicide, 3-10 ppm required. Toxicity range (ppm) given as that which kills 25 percent of the test fish.	Applegate and King (1962)
	Micropterus salmoides			22-42 (O)			
	Micropterus dolomieui			34.5-42 (O)			
	Lepomis macrochirus			21.5-44.0 (O)			
	Stizostedion v. vitreum			5.75-11.5 (O)			
	Perca flavescens			7.25-20.5 (O)			
	Ictalurus natalis			5.75-15.5 (O)			
	Catostomus commersoni			5.0-13.0 (O)			
	Notropis heterolepis			13.25-28.0 (O)			
	Notemigonus crysoleucas			14.75-33.0 (O)			
	Pimephales promelas			16.0-35.5 (O)			
	Salmo gairdnerii			12.0-25.25 (O)			
TFM	Lamprey (larvae) Rainbow trout (fingerlings)	BFR + L	Great Lakes (Mich)	1.5 (K 8 hr) 2.0 (K 2 hr) 3.0 (K 19 hr) 5.0 (K 3 hr)	a	Describes a portable field monitor, using water obtained at the site.	Howell and Marquette (1963)

TFM	Hydra	BSA (L)	–	3.0 (K1A)	a e	All numbers cited are for 100% kill in 22-24 hours. The number given for rainbow trout was for a 60% kill in 22-24 hours. Data were given for fourteen other aquatic species, but they are not included here because of very low toxicity or doubtful data. These included leeches, isopods, scuds, crayfish, stoneflies, dragonflies, waterbugs, water boatmen, mayflies, caddisflies, bloodworms, snipe flies, and snails.	Smith (1967)
	Turbellarians			4.0-8.0 (K1A)			
	Eripidelidae			12.0 (K1A)			
	Burrowing mayflies			12.0 (K1A)			
	Black flies			8.0 (K1A)			
	Clams			16.0 (K1A)			
	Sea lamprey			4.0 (K1A)			
	Rainbow trout			13.0 (O)			
Thanite	*Gambusia affinis*	BSA	–	0.8 (L1)* 0.9 (L1)** *Resistant fish **Nonresistant fish	a	This paper deals with the resistance of mosquito fish to chlorinated hydrocarbon compounds. Resistant fish were not always less sensitive to these chemicals.	Boyd and Ferguson (1964)
Thimet	*Gambusia affinis*	BSA	–	0.05 (K 83%)	a	Chemicals were dissolved in acetone, and tests were run in triplicate. Toxicity is given as average percent fish killed in 24 hr.	Lewallen (1959)
Thimet	*Pimephales promelas*	BSA	–	0.25 (T4A)	a c d e f	The toxicity of this substance was not influenced by the quality of the water (pH, hardness, alkalinity).	Pickering and Henderson (1966)
	Lepomis macrochirus			0.0047 (T4A)			
Thimet	*Leiostomus xanthurus*	BCFCH	–	0.0005 (O)	a	At a concentration of 0.0005 ppm, the following percent acetylcholinesterase activity as compared to controls was found: *L. xanthurus* – 84 *C. variegatus* – 68 *M. cephalus* – 69.	Butler and Johnson (1967)
	Cyprinodon variegatus			0.0005 (O)			
	Mugil cephalus			0.0005 (O)			
Thiodan® I EC2	*Gambusia affinis* *Rana catesbeiana* (tadpoles)	FL	Cal.	0.5 (O)	a c	Mixed populations of the indicated test species contained in cages were exposed to various insecticidal chemicals applied as dilute sprays to ponds 1/16 acre in size. The indicated toxicant concentration is in lb/acre, and resulted in a 100 percent mortality for the fish, and a 100 percent mortality for the tadpoles in 24 hr.	Mulla (1963)
Thiodan® II EC2	*Gambusia affinis* *Rana catesbeiana* (tadpoles)	FL	Cal.	0.5 (O)	a c	Comment same as above.	Mulla (1963)
Thiodan (tech, 96.6 percent)	*Pimephales promelas*	BSA	–	0.0033 (T4A)	a c d e f	The toxicity of this substance was not influenced by the quality of the water (pH, hardness, alkalinity).	Pickering and Henderson (1966)
	Lebistes reticulatus			0.0037 (T4A)			
Thiram	Channel catfish (fingerlings)	BSA	–	>1.0 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)

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Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Tiguron	*Salmo gairdneri*	BSA	–	4.35 (T2A)	a f	Variance and the 95 percent confidence interval (C.I.) were also determined.	Willford (1966)
	Salmo trutta			3.62 (T2A)			
	Salvelinus fontinalis			5.50 (T2A)			
	Salvelinus namaycush			5.30 (T2A)			
	Ictalurus punctatus			5.90 (T2A)			
	Lepomis macrochirus			8.90 (T2A)			
Tillam	*Crassostrea virginica*	BCFA & BSA	–	1.0 (O, 20%)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
	Penaeus duorarum			1.0 (NTE)			
	Penaeus setiferus						
	Leiostomus xanthurus			6.3 (T2A)			
	Fundulus similis						
	Mugil cephalus						
	Cyprinodon variegatus						
	Phytoplankton			24% (O)			
TNT	*Lythrurus umbratilis*	BSA	–	(O)	a c f l o	All sensitive and young stages of fish died in concentrations of TNT red liquor waste greater than approximately 1 to 600 dilution of average samples as described by Mohlman (17 to 18 C). Increase in water temperature decreased survival time of the fish in TNT waste and smaller specimens died sooner than larger.	Degani (1943)
	Hyborhynchus notatus						
	Cyprinella whippli						
	Helioperca incisor						
	Gambusia affinis						
	Cristivomer n. namaycush						
	Ericymba buccata						
	Cyprinus carpio						
	Ameiurus melas						
	Moxostoma aureolum						

	Chaenobryttus gulosus *Lepomis cyanellus*						
Tordon	*Lepomis macrochirus*	BSA	–	43 (T1A)	a b e	This report is a simple and straightforward determination of a median tolerance limit for a selected group of herbicides.	Hughes and Davis (1967)
Tordon	*Crassostrea virginica* *Penaeus aztecus* *Mugil cephalus* Phytoplankton	BCFA & BSA	–	1.0 (NTE) 1.0 (NTE) 1.0 (NTE) (O)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
Tordon 101	*Penaeus aztecus*	L	–	(O)	a	Toxicant chemicals were evaluated in seawater at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality. No effect occurred at 1.0 ppm.	Butler (1965)
Tordon 101	Oyster	BCF	–	(O)	a	No effect on exposure to the chemical at 1.0 ppm.	Butler (1965)
Tordon	*Mugil cephalus* (juvenile)	BSA	–	(O)	a	Water temperature was 28 C. No effect was noticed on exposure to 1.0 ppm.	Butler (1965)
Tordon	Rainbow trout Bluegill	BSA	–	2.4 (T2A) 13.1 (T2A)	–	Data are given as LC_{50}.	Bohmont (1967)
Toxaphene	*Lepomis macrochirus* *Notemigonus crysoleucas* *Micropterus salmoides*	FL	Auburn, Ala.	(O)	–	0.02 ppm killed bluegills and golden shiners. The bass were killed at 0.04 ppm. 0.2 ppm in an earthen pond killed bluegill and bass fingerlings and bait-sized goldfish in 45 hours.	Lawrence (1950)
Toxaphene	Carp *Perca flavescens* Golden shiners	FL	Beckers Lake, Ariz.	0.1 (K)	a b c g	All fish died during an eleven-day period. The lake was successfully stocked about 8 months later with rainbow trout.	Hemphill (1954)
Toxaphene	Carp *Gila robusta elegans* Largemouth bass Bluegill Brown trout Bullhead catfish	FL	Lyman Reservoir, Ariz.	0.1 (K)	a b c g	All fish died during a two-day period. The reservoir was successfully stocked 10 months later with rainbow trout.	Hemphill (1954)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Toxaphene	*Pimephales promelas*	BSA	–	0.036 (T1A) 0.020 (T1A) 0.0057 (T1A) 0.1 (O)	a c d f	At 50 F and 6 ppm methyl orange alkalinity. At 50 F and 212 ppm methyl orange alkalinity. At 75 F and 212 ppm methyl orange alkalinity. At 212 ppm methyl orange alkalinity, 75 F, no aeration, 6.4-7.0 ppm dissolved O_2 and with light, 100% mortality occurred in 2 days. Toxicant was added immediately before fish.	Hooper and Grzenda (1955)
				0.060 (T1A) 0.10 (T1A) 1.5 (T1A) 9.5 (T1A)		At 55 F and 212 ppm methyl orange alkalinity. At 55 F and 212 ppm methyl orange alkalinity. At 55 F and 212 ppm methyl orange alkalinity. At 55 F and 212 ppm methyl orange alkalinity. The chemical becomes detoxified when left standing in water by removal by microorganisms. The chemical is more toxic to fish in hard water than in soft water. 0.05 ppm emulsified toxaphene is sufficient for fish eradication. Somewhat lower concentrations can be used in shallow hard water lakes with a higher temperature.	
Toxaphene	*Tendipedae* *Chaoborus* spp	FL	Colo.	0.1 (K3) (O)	a c d e	This is a study of lake bottom fauna. Repopulation of lake was not complete until nine months later.	Cushing and Olive (1957)
Toxaphene	Bluegill Pumpkinseed Largemouth bass Yellow perch Rock bass	FL	Lakes (Mich.)	0.005 (K)	d	Toxaphene at the indicated concentration killed the majority of small fish while larger fish were not killed. According to the authors, toxaphene at a 5 ppb concentration can be used to reduce the population of small fish without greatly affecting the population of large fish.	Fukano and Hooper (1958)
Toxaphene	Bullhead	BSA	–	<0.001 (T1A)	a	It was estimated that 25.0 ppb will eradicate an entire fish population in a lake. A concentration of 20.0 ppb seemed sufficient to kill all fish in aquarium tests. In highly turbid water, 200 ppb were required. This suggests that the silt in suspension has a detoxifying effect. The field study reports what is believed to be the first instance in which a lake is rid of all fish by chemical means. Bottom fauna declined in volume due to the treatment but recovered rapidly (1 mo).	Rose (1958)
	Bullhead	F	Iowa	0.005 (O)	–		
	Carp			0.005 (O)			
	Bottom fauna			–			
Toxaphene	*Catostomus macrocheilus*	FL	Spectacle Lake, British Columbia	0.07 (O)	a c d	Experiments were conducted in 8 lakes in British Columbia, all of which were alkaline. These lakes had no permanent inlet or outlet streams. Initial results or symptoms were observed in 120 hr. All caged fish were dead except 2 carp which managed to survive for 1 to 2 months.	Stringer and McMynn (1958)
	Ptychocheilus oregonense			0.07 (O)			
	Cyprinus carpio			0.07 (O)			
	Richardsonius balteatus			0.07 (O)			
	Mylocheilus caurinum			0.07 (O)			

Toxaphene	*Catostomus macrocheilus*	FL	Lady King Lake, British Columbia		a c d	Experiments were conducted in 8 lakes in British Columbia, all of which were alkaline. These lakes had no permanent inlet or outlet streams. There was no sign of fish life after 24 hr.	Stringer and McMynn (1958)
	Ptychocheilus oregonense			0.10 (K2)			
	Cyprinus carpio						
	Richardsonius balteatus			0.10 (K2)			
	Perca flavescens						
	Mylocheilus caurinum			0.10 (K2)			
	Couesius plumbeus						
	Coregonus williamsoni						
	Oncorhynhus nerka						
	Salmo gairdneri			0.10 (K2)			
	Lottus asper			0.10 (K2)			
Toxaphene	*Catostomus macrocheilus*	FL	Gallagher Lake, British Columbia	0.07 (K2)	a c d	Experiments were conducted in 8 lakes in British Columbia, all of which were alkaline. These lakes had no permanent inlet or outlet streams.	Stringer and McMynn (1958)
	Ptychocheilus oregonense			0.07 (K2)			
	Richardsonius balteatus			0.07 (K2)			
	Perca flavescens			0.07 (K2)			
	Mylocheilus caurinum			0.07 (K2)			
	Couesius plumbeus			0.07 (K2)			
	Coregonus williamsoni			0.07 (K2)			
	Oncorhynhus nerka			0.07 (K2)			
	Salmo gairdneri			0.07 (K2)			
Toxaphene	*Catostomus macrocheilus*	FL	Gladstone Lake, British Columbia	0.03 (O)	a c d	Experiments were conducted in 8 lakes in British Columbia, all of which were alkaline. These lakes had no permanent inlet or outlet streams. In 12 hours many trout and shiners were dead; all other fish showed signs of distress.	Stringer and McMynn (1958)
	Cyprinus carpio			0.03 (O)			
	Richardsonius balteatus			0.03 (O)			
	Mylocheilus caurinum			0.03 (O)			
	Salmo gairdneri			0.03 (O)			

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Toxaphene	*Catostomus macrocheilus* *Ptychocheilus oregonense* *Cyprinus carpio* *Richardsonius balteatus* *Mylocheilus caurinum* *Salmo gairdneri*	FL	Taylor Lake, British Columbia	0.01 (K4) 0.01 (K4) 0.01 (K4) 0.01 (O) 0.01 (K4) 0.01 (O)	a c d	Experiments were conducted in 8 lakes in British Columbia, all of which were alkaline. These lakes had no permanent inlet or outlet streams. Rainbow trout and shiners showed definite signs of distress in 4 days.	Stringer and McMynn (1958)
Toxaphene	*Catostomus macrocheilus* *Salmo gairdneri*	FL	Alleyne Lake, British Columbia	0.01 (O) 0.01 (O)	a c d	Experiments were conducted in 8 lakes in British Columbia, all of which were alkaline. These lakes had no permanent inlet or outlet streams. In 24-48 hours many fish were dead while others were still in distress.	Stringer and McMynn (1958)
Toxaphene	*Cyprinus carpio*	FL	Round Lake, British Columbia	0.03 (K3)	a c d	Experiments were conducted in 8 lakes in British Columbia, all of which were alkaline. These lakes had no permanent inlet or outlet streams.	Stringer and McMynn (1958)
Toxaphene	*Catostomus macrocheilus* *Ptychocheilus oregonense* *Cyprinus carpio* *Richardsonius balteatus* *Mylocheilus caurinum* *Salmo gairdneri*	FL	Summit Lake, British Columbia	0.10 (O) 0.10 (O) 0.10 (O) 0.10 (O) 0.10 (O) 0.10 (O)	a c d	Experiments were conducted in 8 lakes in British Columbia, all of which were alkaline. These lakes had no permanent inlet or outlet streams. Initial results were recorded in 4 hours. Many dead trout and shiners were observed. All caged fish were dead in 2 days.	Stringer and McMynn (1958)
Toxaphene	Fathead minnow	BSA	–	0.0051 (T4A)	a	It was the authors opinion that pH, alkalinity and hardness, within the usual range in natural waters, had little effect on the toxic effect of the compounds studied. The values given are from Henderson, Pickering, and Tarzwell, "The Relative Toxicity of Ten Chlorinated Hydrocarbon Insecticides to Four Species of Fish". It is interesting that the different tables from the above book (as reported in this paper) report widely different values for the same compounds. This experiment was performed in hard water.	Tarzwell (1959)
Toxaphene	Fathead minnow Bluegill Goldfish Guppy	BSA	–	0.0075 (T4A) 0.0035 (T4A) 0.0056 (T4A) 0.020 (T4A)	a	Comment same as above except that this experiment was performed in soft water.	Tarzwell (1959)

Toxaphene	*Pimephales promelas* *Lepomis macrochirus*	BSA	–	0.0075 (T4A) 0.0035 (T4A)	a	Bioassay investigations of the new insecticides indicate that in general the organic phosphorus compounds are not as toxic to fish as are the chlorinated hydrocarbons. The toxicity of most of these materials was not significantly influenced by water quality. Therefore it is to be expected that the toxicity of these materials will not differ significantly in different streams.	Tarzwell (1959)
Toxaphene	Channel catfish (fingerlings)	BSA	–	2.5 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Toxaphene	*Pimephales promelas* *Lepomis macrochirus* *Carassius auratus* *Lebistes reticulatus*	BSA	–	0.008 (T4A) 0.004 (T4A) 0.006 (T4A) 0.02 (T4A)	a d e f	Concentrations were based on percent active ingredient.	Henderson, et al (1960)
Toxaphene (100%)	*Pimephales promelas* *Lepomis macrochirus* *Carassius auratus* *Lebistes reticulatus*	BSA	–	0.0075 (T4A) 0.0035 (T4A) 0.0056 (T4A) 0.020 (T4A)	a b e c d f	Dilution water was usually soft although some studies were conducted with hard water.	Henderson, et al (1959)
Toxaphene (tech)	*Lepomis cyanellus* *Onchorhynchus nerka* *Notropis* sp *Daphnia pulex* *D. magna* *Ischnura* sp *Enallagma* sp *Scenedesmus incrassatulus*	BSCH	–	0.0036 (SC4) 0.0036 (SC4) 0.01 (SC4) 0.03 (SC7) 0.03 (SC5) 0.004 (SC4) 0.004 (SC4) 0.01 (SC384)	a e p	Toxicity is reported as the sublethal concentration (SC), which is defined as that concentration which produced no greater mortality among test animals than was sustained by the controls. In fish study, test fish were challenged with solvent extracts of toxaphene-exposed algae and periphyton. Fish tested against the algae extract survived, but fish tested against periphyton extracts died. Various technical grades of toxaphene were evaluated.	Schoettger and Olive (1961)
Toxaphene	*Pimephales promelas*	BSA	–	0.013 (T4A)	a c d f g	Test water was spring water diluted with distilled water. Removal of toxic chemicals by carbon adsorption, chlorine and chlorine dioxide treatment, and alum coagulation was studied. The most effective method to remove fish poisons was by use of activated charcoal adsorption.	Cohen, et al (1961)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Toxaphene	Gizzard shad Bluegill Black crappie Largemouth bass Brown bullhead Shortnose gar Golden shiner Bowfin *Gambusia affinis* *Notropis maculatus* *Fundulus seminolis*	FL	Fla.	(O)	c d	A variety of lake types was employed to discern selective fish-killing properties of Toxaphene. Concentrations ranging from 1 to 85 ppb were placed in fourteen bodies of water varying in size from 0.5 to 2100 acres. Differences in concentrations required to cause total kills of fish populations in treated lakes appeared to be related to bicarbonate alkalinities, bottom types, amounts of plankton, vegetation, and the sizes of fish present. In 4 of the lakes, a total fish kill occurred at 15-36 ppb Toxaphene.	Huish (1961)
Toxaphene	*Oncorhynchus kisutch*	BSA	–	9.4 (T4A)	a c d e	Chemical dissolved in acetone. TL_m expressed in ppb.	Katz (1961)
	Oncorhynchus tshawytscha			2.5 (T4A)			
	Salmo gairdnerii			8.4 (T4A)			
	Gasterosteus aculeatus			7.8 (T4A)			
Toxaphene	Entomostraca *Cyclops* *Diaptomus* *Ceriodaphnia* *Bosmina* *Leptodora* Rotaria *Filinia* *Keratella* *Polyarthia* *Asplanchna* *Brachionus* Protozoa *Ceratium* *Difflugia*	FL	Col.	0.1% (K)	a c d g p	All chemical and physical data were collected and compiled by standard limnological techniques. Chemical analyses were conducted monthly. Biweekly plankton collection showed "reduction to zero" of all organisms studied, but recovery of populations to normal population numbers within several months.	Hoffman and Olive (1961)
Toxaphene	*Salmo gairdneri*	BSA	–	(O)	a c d f g	Water employed for this experiment was a relatively hard, alkaline-type taken from 3 sources: Mormon Reservoir, Magic Reservoir, and Redfish Lake. The TL_m given are recorded respectively for each reservoir: 0.0135 (T4), 0.0165 (T4), and 0.0145 (T4).	Webb (1961)

Toxaphene	*Gammarus lacustris lacustris*	BSA	–	(O)	a e p	The mortality might have been partially due to the susceptibility of the organism to higher temperatures, toxicity from extended exposure to copper electrodes (used to shock the organism to determine death), or the increase of CO_2. Results were expressed as LT_{50}; for example, at 0.5 ppm, 50 percent of the shrimp were killed in 96 (± 11) min.	McDonald (1962)
Toxaphene	*Protococcus* sp *Chlorella* sp *Dunaliella euchlora* *Phaeodactylum tricornutum* *Monochrysis lutheri*	BSA	–	0.15 (K) 0.15 (K) 0.07 (NG) 0.15 (K) 0.04 (NG) 0.04 (K)	a	This paper concerns the growth of pure cultures of marine plankton in the presence of toxicants. Results were expressed as the ratio of optical density of growth in the presence of toxicants to optical density in the basal medium with no added toxicants. NG = no growth, but the organisms were viable.	Ukeles (1962)
Toxaphene	*Salmo gairdneri* *Ictalurus melas* *Lepomis cyanellus* *Pimephales promelas* *I. natalis* *Micropterus dolomieui* *Catastomus commersoni* *Potamageton* spp *Semotilus atromaculatus*	FL	Clayton Lake, N. M.	0.01, 0.02, and 0.02 (O)* *treatments on 3 alternate days during a 6-day period	a c d e f g i o	Paper chromatography was the method used to determine toxaphene residues in some of the species listed. Mortality of native fish and others in live cars was 100%. Residues in water and sediments were also determined. Residues were as much as 4.2 ppm in dead trout following first treatment, and as much as 15.2 ppm in dead or dying bullheads several days after the second treatment. Dead trout in live cars contained up to 3.5 ppm toxaphene up to 8 mos following initial treatment. *Potomogeton* spp contained up to 18.3 ppm, 9 days after the final treatment. Although the lake was still toxic 9 months after treatment, planting of rainbow trout was successful 12 months after treatment.	Kallman, et al (1962)
Toxaphene (EC8)	*Gambusia affinis* *Rana catesbeiana* (tadpoles)	FL	Cal.	0.5 (O)	a c	Mixed populations of the indicated test species contained in cages were exposed to various insecticidal chemicals applied as dilute sprays to ponds 1/16 acre in size. The indicated toxicant concentration is in lb/acre, and resulted in a 100 percent mortality for the fish, and a 100 percent mortality for the tadpoles in 24 hr.	Mulla (1963)
Toxaphene	Fish	FL	Mont.	0.13 (O)	a c d e l	Ponds were treated with the chemical to eradicate fish. The fish population included largemouth bass, bluegills, black crappie, yellow perch, carp, white sucker, and longnose sucker. Counts were made of various fish at various later times. The paper contains little quantitative data.	Wollitz (1963)
Toxaphene	*Carassius auratus* *Gambusia affinis* *Salmo gairdnerii*	BSA	–	0.005-0.066 (O) 0.005-0.059 (O) 0.013-0.064 (O)	a c d e	Natural water from various sources were used. Chemical added as either floating or sinking type formulations. Toxicity given as LC_{50} in ppm.	Workman and Newhold (1963)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Toxaphene	*Notemigonus crysoleucas* *Lepomis macrochirus* *L. cyanellus*	BSA	–	(B) 30 (T 1.5) (A) 1200 (T 1.5) (B) 23 (T 1.5) (A) 1600 (T 1.5) (B) 38 (T 1.5) (A) 1500 (T 1.5)	a c f	Chemical was dissolved in acetone. Final concentration of acetone was <2 ml/l. Data shows TL_m ppb for insecticide-resistant (A) and insecticide nonresistant (B) strains of the test fish.	Ferguson, et al (1964)
Toxaphene	*Gambusia affinis affinis*	BSA	–	0.01 to 0.48 (O)	a	The lower value is for fish that had never been exposed to the toxicant, and the higher value was obtained with fish that had been exposed to a sublethal dose in the past. Apparently such an exposure produces a resistance that can be retained when they are later placed in clean water.	Boyd and Ferguson (1964)
Toxaphene	–	FR	Flint Creek, Ala.	0.210 (K)	–	Conventional treatment in a water purification plant did not reduce the amount of chemical found in the stream. Data are given for 4 years 1959-62, with a range of concentrations. Only the highest value is reported here. Some fish kill is reported, but species are not identified here. Data are also reported for all seasons to show variation; the one listed here is for summer 1960.	Nicholson, et al (1964)
Toxaphene	Bluegill	BSA	–	0.0035 (T4A)	a	Assays were conducted in soft water at 25 C. Decrease in brain cholinesterase was measured in fish exposed to the toxicant.	Weiss (1964)
Toxaphene	*Leiostomus xanthurus*	BSFCHA	–	0.003 (K)	a o	Assays were performed in seawater and results are reported simply as number dead. Concentrations above 0.0032 ppm killed all test animals in 24 hr. Fish were also exposed to 0.01 ppb and 0.1 ppb for 5 months, and growth was not different from those in the wild populations.	Lowe (1964)
Toxaphene	*Palaemonetes kadiakensis*	BSA	–	(N) 57.5 (T1½A) (TB) 170.0 (T1½A)	a c f	Test organisms were collected from 2 locations, Twin Bayou (TB), Sunflower Co., Miss. (Agricultural area) and Noxubee National Wildlife Refuge (N), Noxubee Co., Miss. (non-agricultural area) and evaluated in laboratory bioassays.	Ferguson, et al (1965)
Toxaphene	*Gambusia affinis* *Ictalurus melas*	BSA	–	0.01-0.04 (T3A) 0.004-0.050 (T3A)	a c d e	Test fish were collected from 8 different locations of the Mississippi River. The 3-day TL_m values were made to determine if a resistance gradient existed. The data indicated that there was none.	Ferguson (1965)
Toxaphene	Rainbow trout	BSA	–	5.4 (T4A) 2.7 (T4A) 1.8 (T4A)	a	These experiments were performed to show the effect of temperature on the toxicity. For the toxicant concentrations listed, the temperatures were respectively 45, 55, and 65 F. The fish all were approximately one grain in weight. Toxicant concentrations for one and 2-day times were also listed.	Cope (1965)

Toxaphene	Fish	FL	Wis.	0.1 (K)	–	Elimination of fish population was accomplished with toxaphene at the indicated concentration. This is a population succession study over a 3-year period with observations on change in populations due to various ecological factors.	Hilsenhoff (1965)
	Chironomus (larvae and pupae)			(O)			
	Chaoborus (larvae and pupae)			(O)			
	Physidae			(O)			
	Crustaceans			(O)			
Toxaphene	*Salmo gairdneri*	BSA	–	0.0084 (T4A)	a c d e f i m p	Adult fish were employed in this bioassay. In most cases, concentrations of toxaphene needed to cause 50 percent mortality decreased as the temperature increased from 53 F to 63 F and to 73 F. Data cited are for 53 F.	Mahdi (1966)
	Campostoma anomalum			0.014 (T4A)			
	Carassius auratus			0.094 (T4A)			
	Notemigonus crysoleucas			0.0125 (T4A)			
	Pimephales notatus			0.03 (T4A)			
	Ictalurus melas			0.025 (T4A)			
Toxaphene	*Oncorhynchus garbuscha* *O. keta* *O. kisutch* *Cottus aleuticus* *Salvelinus malmo* *Gasterosteus aculeatus* *Salmo gairdnerii* *Oncorhynchus nerka* *Pholis laeta* *Osmeridae*	FR	Big Kitoi Creek, Alaska	(O)	–	The purpose of this experiment was to determine the extent of predation by sculpins on pink salmon fry, and the effects of toxaphene on the sculpins and bottom fauna. Toxaphene applied to the experimental area was estimated to be an average concentration of 1.5 ppm. At the above concentration insects were completely eradicated, bottom fauna decreased in numbers and weight, but some other invertebrate groups were not completely eliminated. The organisms listed were organisms mentioned as fauna in the experimental area.	Meehan and Sheridan (1966)
Toxaphene	Fish	FL	Brush and Long Lakes, N. D.	(C'	–	Growth rates for yellow perch that survived a toxaphene treatment in Brush and Long Lakes in North Dakota were calculated. Brush Lake fish exhibited greatly increased growth rates for two growing seasons following the treatment. Increased growth rates were not evident for Long Lake fish until the next growing season. The approximate concentration of toxaphene for reducing the density of fish populations is believed to be 25 percent of the rate determined for fish eradication in most N. Dakota waters.	Warnick (1966)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Toxaphene	*Polyarthra* *Keratella* *Asplanchna* *Conochiloides* *Brachionus* *Trichocera* *Daphnia* *Bosmina* *Ceriodaphnia* *Cyclops* Cyanophyta	FL	Various lakes or reservoirs, N. D.	–	a	Marked reduction of many plankters followed a treatment of 90 ppb toxaphene. The most abundant plant-inhabiting organism and bottom fauna exhibited no marked changes after this treatment. Populations of *Gammarus*, *Physa*, and *Gyraulus* remained constant, while *Callibaetis*, *Caenis*, *Ischnura*, and *Tendipes* decreased slightly but were again numerous 1 year after treatment.	Needham (1966)
Toxaphene	*Lebistes reticulatus*	BSA & FL	Canada	0.001 (T2A)	a c e	A bioassay method is described for determining the rate of detoxification of lake water after toxaphene treatment during a 1-year period.	Royer (1966)
Toxaphene	*Carassius auratus*	BCF	–	11.0 mg/l (T4CF) 0.44-1.8 mg/l (S4)	–	This method was developed to detect sublethal effects by observing behavioral aberrations. Detailed description of conditioned avoidance response apparatus is presented.	Warner, et al (1966)
Toxaphene	*Simocephalus serrulatus* *Daphnia pulex*	BSA	–	0.019 (SB) 0.015 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 48 hr. Data cited are for 60 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
Toxaphene	Fish	F	Cal.	(O)	–	This study was primarily concerned with insecticides found in fish-eating birds. Limited fish studies were also conducted. Toxaphene was found in trace to 8.0 ppm concentrations in whole fish (wet weight).	Keith (1966)
Toxaphene	*Salmo gairdneri* *Lepomis macrochirus* *Pteronarcys californicus* *Baetis* sp *Daphnia pulex* *Simocephalus serrulatus*	BSA	–	0.004 (T2A) 0.004 (T2A) 0.007 (T2A) 0.047 (T2A) 0.015 (T2A) 0.019 (T2A)	a	This paper reports acute toxicity of a number of compounds, and discusses sub-acute mortality as well. Effects on reproduction and behavior are also discussed. Data presented as EC_{50}.	Cope (1966)
Toxaphene	*Petromyzon marinus* (larvae)	FL BSA	East Bay, Alger County, Mich. –	(O) 0.080 (K15-20)	a c e	The amount of toxicant needed to give a concentration of 100 ppb (0.100 ppm) was applied over the surface of the lake. Small fish were observed surfacing and dying the day after treatment was made. Mortality increased daily and reached a peak on the 3rd and 4th days. The first dead larval lampreys were seen on the 4th day after treatment. At the end of 36 days exposure in cages, only 2 of 90 ammocetes were alive.	Gaylord and Smith (1966)

Toxaphene	*Carassius auratus* *Salmo gairdnerii*	FL	Big Bear Lake, Cal.	0.3-0.10 (O)	a c	The chemical was sprayed from a plane into the lake to rid it of goldfish. Small fish began dying in 2 hours, and brown bullheads were seen to be in distress. At 0.10 ppm, large goldfish appeared to be in distress. An estimated 95% of the goldfish, and all the other fish were eliminated. The fat and flesh of goldfish, brown bullheads, and some trout were analyzed for the toxicant. In all instances the fat contained the greatest amount. The paper recommends that toxaphene not be used as a fish toxicant, because it detoxifies slowly and is a contaminant for an unknown period of time. Some trout were killed when stocked but no quantitative data are given.	Johnson (1966)
Toxaphene	*Salmo gairdneri* *Esox lucius* *Cyprinus carpio* *Notemigonus crysoleucas* *Pimephales notatus* *Catastomus commersoni* *Ictalurus melas* *Ictalurus nebulosus* *Lepomis humilis* *Lepomis macrochirus* *Pomoxis annularis* *Pomoxis nigromaculatus* *Perca flavescens* *Stizostedion vitreum*	FL	Various lakes, N. D.	0.035 (O)	–	Minimum levels of toxaphene lethal to fish in prairie lakes and reservoirs were determined. Considering all lakes in general, 0.005 to 0.020 ppm resulted in incomplete mortality, while 0.025 to 0.035 ppm resulted in complete mortality. The minimum lethal concentration for treatment of most North Dakota lakes was 0.025 ppm of toxaphene.	Henegar (1966)
Toxaphene	*Gambusia affinis*	BSA	–	(O)	a	The effect of combinations of pesticides was studied. In general, the results reflected the extreme levels of Endrin and Toxaphene resistance in the resistant population. The results failed to indicate additive effects wherein the combination mortality exceeded the sum of the mortalities produced by the individual insecticides.	Ferguson and Bingham (1966)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Toxaphene	*Pimephales promelas*	BSA	–	0.05 (K9) 0.02 (K21) 0.05 (K6) 0.02 (K11)	a b	At 33 to 39 F a complete kill occurred at concentrations of 0.05 and 0.02 in 9 and 21 days, respectively. At 56 F a complete kill occurred at concentrations of 0.05 and 0.02 ppm in 6 and 11 days, respectively. Toxaphene will kill fish at near-freezing temperatures at concentration as low as 0.02 ppm but the length of time required for a complete kill is longer than at higher temperatures.	Schaumberg, et al (1967)
Toxaphene	*Leiostomus xanthurus*	BCF	–	0.0075 (K1A) 0.0056 (K1A) 0.0032 (K1A) 0.0018 (K2A) 0.0001 (SB 5 mo) 0.00001 (SB 5 mo)	a	Experiments were conducted in salt water. Fish were held in plastic aquaria with a capacity of 25 liters. During the 5-month exposure period there was no significant difference in mortality among control and experimental fish. No symptoms of distress were noted. The total lengths of the fish at the end of 5 months were approximately the same for all groups. After the 5-month test the fish from the experimental and the control groups were exposed 48 hours to concentrations of 0.0005 to 0.0030 ppm. The fish from the experimental group seemed to be more sensitive. Concentrations of 0.0020 ppm caused complete kill whereas 0.0005 ppm did not kill any fish.	Kaplan and Overpeck (1967)
Toxaphene	*Pteronarcys californica* (naiads)	BSA	–	0.0023 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
	Pteronarcella badia (naiads)			0.003 (T4A)			
	Claassenia sabulosa (naiads)			0.0013 (T4A)			
2(2,4,5) TP (tech)	Rainbow trout	BSA	–	14.8 (T4A)	a	This is an estimated LC_{50} value at temperatures from 55 to 75 F.	Cope (1965)
	Bluegill			9.6 (T4A)			
2,4,5-TP	Rainbow trout	BSA	–	1.3 (T2A)	–	Data are given as LC_{50}.	Bohmont (1967)
	Bluegill			0.50 (T2A)			
4(2,4)TP (tech)	Bluegill	BSA	–	8.6 (T4A)	a	This is an estimated LC_{50} value at temperatures from 55 to 75 F.	Cope (1965)
Treflan	*Pteronarcys* sp (nymphs)	BSA	–	3.0 (T4A)	a	Experiments were all conducted at 60 F in 1964. The values were listed as LC_{50}.	Cope (1965)
Treflan (EC)	Rainbow trout	BSA	–	0.010 (T4A)	a	This is an estimated LC_{50} value at temperatures from 55 to 75 F.	Cope (1965)
	Bluegill			0.018 (T4A)			
Treflan	Rainbow trout	BSA	–	0.011 (T2A)	–	Data are given as LC_{50}.	Bohmont (1967)
	Bluegill			0.020 (T2A)			

Trefmid (WP)	Rainbow trout Bluegill	BSA	–	0.110 (T4A) 0.345 (T4A)	a	This is an estimated LC_{50} value at temperatures from 55 to 75 F.	Cope (1965)
Tri-6 (dust No. 30, 3 percent BHC)	*Penaeus aztecus* *P. setiferus*	BSA	–	0.035 (T1A) 0.40 (T1A)	a c	*P. aztecus* and *P. setiferus* ranged in size from 29 to 50 mm and 11 to 13 mm, respectively. The water was aerated until the end of the assay.	Chin and Allen (1957)
Trichlorofon	*Pteronarcys californica* (naiads) *Pteronarcella badia* (naiads) *Claassenia sabulosa* (naiads)	BSA	–	0.035 (T4A) 0.011 (T4A) 0.022 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Tricon (oil spill eradicator)	*Roccus saxatilis*	BSA	–	0.001 (O) 0.005 (K 1 hr) 2.0 (K 7 min)	a	At 0.001 percent, the fish showed signs of distress in 1-1/2 hours. This compound was toxic at low concentrations and should not be used to treat oil spills.	Chadwick (1960)
Tricon oil-spill eradicator	*Roccus saxatilis*	BSA	–	(O)	a	This chemical is a commercial product designed to emulsify oil spilled on water. At 0.0005% concentration all test fish survived. At 0.001% concentration all fish died within 10 hours. Additional data are presented.	Chadwick (1960)
Trifluralin	Bluegill Fathead minnow Goldfish	BSA	–	0.0582 (O) 0.0934 (O) 0.585 (O)	a b	In static soil-water tests, 48 and 227 times more Trifluralin was required to produce an LC_{50} to bluegills for two types of soil than was necessary in the static water tests. In a simulated field test using swimming pools, Trifluralin, applied at 1 lb/acre to Brookston soil and then irrigated with 10 inches of water, was not toxic to bluegills. On the basis of these studies, it was concluded that LC_{50} values derived from static water fish tests are unrealistic in predicting the toxicity of Trifluralin to fish under field conditions.	Parka and Worth (1965)
Trifluralin	Bluegill	BSA	–	8.4 (T4A)* *ppb	a	The temperature effect is extreme in the case of this compound. The T4 listed is for a temperature of 85 F. At 45 F the T4 was 280 ppb. The T1 is even more striking. At 85 F, the value was 10.0 ppb, and at 45 F, 1300 ppb.	Cope (1965)
Trifluralin (tech)	Bluegill Rainbow trout	BSA	–	0.068 (T4A) 0.086 (T4A)	a	This is an estimated LC_{50} value at temperatures from 55 to 75 F.	Cope (1965)
Trifluralin	*Salmo gairdneri* *Lepomis macrochirus* *Pteronarcys californicus* *Daphnia pulex* *Simocephalus serrulatus*	BSA	–	0.011 (T2A) 0.019 (T2A) 4.200 (T2A) 0.240 (T2A) 0.450 (T2A)	a	This paper reports acute toxicity of a number of compounds, and discusses subacute mortality as well. Effects on reproduction and behavior are also discussed. Data presented as EC_{50}.	Cope (1966)

Chemical	Organism	Bioassay or Field Study$^{(1)}$	Field Location$^{(2)}$	Toxicity, Active Ingredient, ppm$^{(3)}$	Experimental Variables Controlled or Noted$^{(4)}$	Comments	Reference (Year)
Trifluralin	*Simocephalus serrulatus*	BSA	–	0.450 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed at varied temperatures. "Water Chemistry" (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
	Daphnia pulex			0.240 (SB)			
Trifluralin	*Pteronarcys californica* (naiads)	BSA	–	0.003 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Tris-buffer	*Homarus americanus*	BSA	–	2200-4400 (SB10)	a c e	Tris-buffer concentrations in the range tested were safe for regulating activity. The lobsters employed weighed 500 grams.	Stewart and Cornick (1964)
Trithion	*Gambusia affinis*	BSA	–	0.2 (K 7%)	a	Chemicals were dissolved in acetone, and tests were run in triplicate. Toxicity is given as average percent fish killed in 24 hr.	Lewallen (1959)
Trithion	*Salmo gairdnerii* (one wk old sac fry)	BSA	–	0.5 (K 0%) 5.0 (K 0%)	a c	Results are averages of triplicate tests. Toxicity is reported as percent mortality (K %).	Lewallen and Wilder (1962)
	(one mo old feeding fry)	BSA		0.5 (K 7%) 5.0 (K 93%)			
Trolene	*Salmo gairdneri*	BSA	–	0.74 (T2A)	a f	Variance and the 95-percent confidence interval (C.I.) were also determined.	Willford (1966)
	Salmo trutta			0.39 (T2A)			
	Salvelinus fontinalis			0.39 (T2A)			
	Salvelinus namaycush			0.62 (T2A)			
	Ictalurus punctatus			1.26 (T2A)			
	Lepomis macrochirus			1.00 (T2A)			
Trypaflavine (acriflavine neutral)	*Ictalurus punctatus*	BSA	–	17.9 (K2) 11.5 (T2A)	a c f i	The experiment was conducted at 66 C.	Clemens and Sneed (1958)
Trypaflavine (acriflavine hydrochloride)	Channel catfish (fingerlings)	BSA	–	11.5 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
TV-1096	*Salmo gairdnerii*	BSA	–	16.1 (T2A)	a f	Variance and the 95-percent confidence interval (C.I.) were also determined.	Willford (1966)
	Salvelinus fontinalis			19.0 (T2A)			
	Salvelinus namaycush			16.5 (T2A)			

	Ictalurus punctatus			20.3 (T2A)			
	Lepomis macrochirus			28.2 (T2A)			
UC-8305 (EC4)	*Gambusia affinis*	FL	Cal.	0.5 (K1)	–	Toxicity value is in lb/acre.	Mulla (1966)
Union Carbide, UC 10854	Rainbow trout	BSA	–	0.180 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
	Bluegill			0.110 (T4A)			
Union Carbide, UC 21149	Rainbow trout	BSA	–	0.560 (T4A)	–	The values reported are given as LC_{50}.	Cope (1965)
	Bluegill			0.050 (T4A)			
UC-21427 (EC2)	*Gambusia affinis*	FL	Cal.	0.5 (K1)	–	Toxicity value is in lb/acre. No mortality in tadpoles of *Rana catesbeiana* occurred during an exposure period of 1 week.	Mulla (1966)
	Rana catesbeiana			(O)			
Urox	Water lettuce	FL	Lakes in Fla.	(O)	–	11.2 to 22.5 lb/acre controlled water lettuce.	Phillippy (1961)
Vancide 51 salt	*Pimephales promelas*	BSA	–	0.83 (T4A)	a c d e f	The toxicity of this substance was not influenced by the quality of the water (pH, hardness, alkalinity).	Pickering and Henderson (1966)
Vancide 51Z	*Pimephales promelas*	BSA	–	0.35 (T4A)	a c d e f	Comment same as above.	Pickering and Henderson (1966)
	Lepomis macrochirus			0.85 (T4A)			
	Lebistes reticulatus			0.59 (T4A)			
Vapona (DDVP)	*Pimephales promelas*	BSA	–	4.0 (T4A)	a c d e f	Comment same as above.	Pickering and Henderson (1966)
	Lepomis macrochirus			0.27 (T4A)			
Veon 100	Spatterdock	FL	Fla.	(O)	–	At 10.0 lb/acre, 5 percent control of spatterdock was obtained.	Copeland and Woods (1959)
Veon 245 (2,4,5-T)	*Crassostrea virginica*	BCFA & BSA	–	1.0 (NTE)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased with shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
	Penaeus aztecus			1.0 (NTE)			
	Leiostomus xanthurus			1.0 (NTE)			
	Phytoplankton			1.0 (NTE)			

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Veon 245	*Leiostomus xanthurus* (juvenile)	BSA	–	(O)	a	Water temperature was 27 C. No effect was noticed on exposure to 1.0 ppm.	Butler (1965)
	Oyster	BCF	–	(O)	a	No effect on exposure to the chemical at 1.0 ppm.	Butler (1965)
	Penaeus aztecus	L	–	(O)	a	Toxicant chemicals were evaluated in seawater at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality. No effect occurred at 1.0 ppm.	Butler (1965)
Vernam	*Crassostrea virginica* *Penaeus aztecus* *Leiostomus xanthurus* Phytoplankton	BCFA & BSA	–	1.0 (NTE) 1.0 (O, 20%) 1.0 (NTE) –	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
Vernam	*Penaeus aztecus*	L	–	(O)	a	Toxicant chemicals were evaluated in seawater at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality. Response irritation occurred at 1.0 ppm.	Butler (1965)
Vernam (tech)	Bluegill	BSA	–	4.0 (T4A)	a	This is an estimated LC_{50} value at temperatures from 55 to 75 F.	Cope (1965)
Vernam	*Leiostomus xanthurus* (juvenile)	BSA	–	(O)	a	Water temperature was 28 C. No effect was noticed on exposure to 1.0 ppm.	Butler (1965)
Vernam	Oyster	BCF	–	(O)	a	No effect on exposure to the chemical at 1.0 ppm.	Butler (1965)
Versenol (iron chelate)	Channel catfish (fingerlings)	BSA	–	1.9 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Versene (acid)	Channel catfish (fingerlings)	BSA	–	167 (K1A)	a	Comment same as above.	Clemens and Sneed (1959)
Weedar, MCP	*Lepomis macrochirus*	BSA	–	(O)	a	No mortality was noted with concentrations of 10,000 mg/l for over 100 hr. The experiment was conducted at 65 F. Fish were 2 in. long.	Cope (1963)
Weedex	*Gardonus rutilus* *Tinca tinca* (fry)	FL	France	(NTE) (K)	–	Eight small ponds were studied. The chemical was nontoxic to larger fish, but toxic to the fry. Ponds were emptied after one month of exposure to the chemical.	Vivier and Nisbet (1965)

Weedex (Weedazol, Weedazol T. L.)	*Phoxinus phoxinus*	BSA	–	(O)	a c d e	The assays were conducted in dual aquaria with aeration. Toxicity was low after 1 month at normally used concentrations, as follows: weedex – 40-80 ppm; weedazol – 15-30 ppm; weedazol – 20-40 ppm.	Vivier and Nisbet (1965)
Weptachlor	*Daphnia magna*	BSA	–	0.052 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 64 hr. Data cited are for 78 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
WL 8008 (isobutyl-triphenyl-methylamine)	*Bulinus truncatus* *Biomorpholaria alexandrina* *Lymnaea caillaudi*	FO	Arabia	0.24-0.25 (O)	a b g	Tests were conducted in the Khurshid canal. Flow of molluscicide was discharged directly into the canal and was maintained at a concentration of 0.24 ppm during the 6 hr of treatment. Formulation 1 killed all adult organisms but did not affect eggs. Snail density reached its pretreatment level after 4 months. Formulation 2 was tested in Ganabiet el Sarania canal. Molluscicide was applied for 6 hr by motor-operated dispenser to give a concentration of 0.25 ppm. Adult organisms were killed while eggs were unaffected.	Dawood and Dazo (1966)
WL 8008 (n-trityl-morpholine)	*Australorbis glabratus*	BSA & FL	Puerto Rico	Variable	c	Seven of the tested compounds failed to meet acceptability criteria – that is, complete kill after 6-hr exposure to 10 ppm. They were not used in field tests. Field tests showed WL 8008 to be highly effective.	Seiffer and Schoof (1967)
Xylene + 2% nonionic emulsifier		BSA			a	Experiments were conducted in standing water. Results were rated on a scale of 0 to 10, 0 standing for no toxic effect and 10 signifying a complete kill. Evaluation was based on visual observation of the plant response at weekly intervals for 4 weeks.	Frank, et al (1961)
	Elodea canadensis			5 (O)		No toxic effect.	
				100 (O)		Injury rating of 9.3.	
	Potamogeton nodosus			5 (O)		No toxic effect.	
				100 (O)		Injury rating of 7.9.	
	Potamogeton pectinatus			5 (O)		No toxic effect.	
				100 (O)		Injury rating of 8.6.	
Zinc dimethyl dithio-carbamate (ZDD)	*Pimephales promelas*	BSA	–	(O)	a c d e f	Toxicity to 30 species of algae are also presented. ZDD was algicidal in the range 0.25 to 2.0 ppm.	Maloney and Palmer (1956)
Zectran	*Penaeus aztecus*	L	–	0.0068 (O)	a	Toxicant chemicals were evaluated in sea water at temperatures averaging about 28 C. The values are for 24-hr EC_{50} or enough to cause loss of equilibrium or mortality.	Butler (1965)
Zectran	*Cyprinodon variegatus* (juvenile)	BSA	–	(O)	a	Water temperature was 12 C. No effect was noticed on exposure to 1.0 ppm.	Butler (1965)
Zectran	Oyster	BCF	–	(O)	a	No effect on exposure to the chemical at 1.0 ppm.	Butler (1965)

Chemical	Organism	Bioassay or Field Study(1)	Field Location(2)	Toxicity, Active Ingredient, ppm(3)	Experimental Variables Controlled or Noted(4)	Comments	Reference (Year)
Zectran	*Pteronarcys californica* (naiads)	BSA	–	0.010 (T4A)	a c d e f	Data reported as LC_{50} at 15.5 C in 4 days.	Sanders and Cope (1968)
Zectran	*Simocephalus serrulatus*	BSA	–	0.013 (SB)	–	Concentration reported is for immobilization. Time for immobilization was 48 hr. Data cited are for 60 F, but assays were performed at varied temperatures. Water chemistry (unspecified) was "controlled" during the assay period.	Sanders and Cope (1966)
	Daphnia pulex			0.010 (SB)			
Zerlate	Channel catfish (fingerlings)	BSA	–	1.0 (K1A)	a	Tap water was used. Considerable additional data are presented.	Clemens and Sneed (1959)
Zinc disodium versenate	Channel catfish (fingerlings)	BSA	–	>500 (K1A)	a	Comment same as above.	Clemens and Sneed (1959)
Zinophos (EC4)	*Micropterus salmoides*	BSA	–	0.25 (T2A) 0.5 (K2) 1.0 (K1)	a e	Experiments were carried out in fiber glass tubs filled with well water. Fish weights ranged from 2 to 6 pounds.	Mulla, et al (1967)
Zytron	Oyster	BCF	–	0.33 (O)	a	The value reported in a 96-hr EC_{50} (decreased shell growth).	Butler (1965)
Zytron	*Leiostomus xanthurus* (juvenile)	BSA	–	0.32 (O)	a	Water temperature was 27 C. The figure reported is a 48-hr EC_{50}.	Butler (1965)
Zytron	*Crassostrea virginica*	BCFA & BSA	–	0.33 (O)	–	Seawater was pumped continuously into test aquaria. Salinity, temperature, and plankton fluctuated with tide, and ambient weather conditions. Some bioassays with fish were static. Toxicity was reported for the following: Oyster – 96-hr EC_{50} – Conc. which decreased shell growth. Shrimp – 48-hr EC_{50} – Conc. which killed or paralyzed 50% of test animals. Fish – 48-hr EC_{50} – Conc. which killed 50%. Phytoplankton – Percent decrease of CO_2 fixation to a 4-hr exposure at 1.0 ppm chemical concentration.	Butler (1965)
	Penaeus aztecus			0.0063 (O)			
	Leiostomus xanthurus			0.32 (T2CFA)			
	Phytoplankton			59% (O)			

APPENDIX C

SPECIES INDEX
FOR
APPENDICES A AND B

APPENDIX C

SPECIES INDEX FOR APPENDICES A AND B

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APPENDIX D

IDENTIFICATION OF COMMERCIAL CHEMICALS

APPENDIX D

Trade Name	Chemical Name or Active Ingredient
2,4D	2,4-dichlorophenoxyacetic acid
2,4,5-T	2,4,5-trichlorophenoxyacetic acid
Abate®	o,o,o',o'-tetramethyl o,o'-thiodi-p-phenylene phosphorothioate
ABS	Alkyl benzene sulfonate
AC 5727	m-isopropylphenyl-N-methylcarbamate
AC 12009	No information available
AC 38023	o,o-dimethyl o,p-(dimethylsulfamoyl) phenyl phosphorothioate
AC 43064	Cyclic ethylene (diethoxyphosphinothioyl) dithiomidocarbonate
AC 43913	See Abate
AC 47031	Cyclic ethylene (diethoxyphosphinyl) dithioimidocarbonate
AC 47921 EC4	No information available
AC 52160	No information available
ACP-M-569	Contains 3-amino-1,2,4-triazole
Acriflavine	A mixture of 2,8-diamino-10-methylacridinium chloride and 2,8-diaminoacridine
Acrolein	Acrylic aldehyde
Acti-dione®	See cycloheximide
Aerosporin	Polymyxin B
Aldrin (Octalene®)	1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4-endo-exo-5,8-dimethanonaphthalene
Algeeclear	No information available
Algibiol	No information available
Algimaster	Alkyl quaternary ammonium bromides, organic polyamine, amine hydrobromides
Algimycin	No information available
Alticide	Sodium chlorate
Ametryne (Ametryn®)	2-ethylamino-4-isopropylamino-6-merthyl-mercapto-s-triazine
Aminotriazole	See Amitrole
Amitrole (Aminotriazole, Amitrol)	3-amino-1,2,4-triazole
Amitrol T	3-amino-1,2,4-triazole-ammonium thiocyanate mixture
Amiton	o,o-diethyl 5,2-diethylaminoethyl phosphorothioate
Ammate	Ammonium sulfamate
Amopyroquin	No information available
Antimycin A	No information available

Trade Name	Chemical Name or Active Ingredient
Aquaherb	o-dichlorobenzene and aromatic salt
Aqualin	85% acrolein
Aquathol®	Disodium salt of endothal (19.2%-H-Pennsalt)
Aramite®	2-(p-tert-butylphenoxy) isopropyl-2'-chloroethyl sulfite
Atabrine	6-chloro-9{[4-(diethylamino)-1-methylbutyl]amino} 2-methoxyacridine dihydrochloride
Atlacide-2,4-D	Sodium chlorate-2,3-dichloroxyacetic acid
Atlas 1901	No information available
Atlas A	Sodium arsenite
Atlox	A series of pesticide emulsifiers
Atrazine (Gesaprim®)	2-chloro-4-ethylamino-6-isopropylamino-s-triazine
Banvel-D®	See Dicamba
Baron®	See Erbon
Barthrin	6-chloropiperonyl chrysanthemumate
Bayer 73	5,2'-dichloro-4'-nitrosalicylanilide
Bayer 4731	No information available
Bayer 9018	No information available
Bayer 22408	o,o-diethyl-o-naphthylamido phosphorothioate
Bayer 25141	o,o-diethyl-o,p-(methylsulfinyl)phenyl phosphorothioate
Bayer 25198	o,o-dimethyl-o-(p-methylsulfinylphenyl) phosphorothioate
Bayer 29492	o,o-diethyl o-(4-methylthio-m-tolyl) phosphorothioate
Bayer 29493 (Baytex® & Fenthion)	o,o-dimethyl-o-[4-(methylthio)-m-tolyl] phosphorothioate
Bayer 29952	o-ethyl-o-(p-methylthio) phenyl methyl-phosphonothioate
Bayer 30749	No information available
Bayer 34042	o-ethyl o-(4-methylthio-m-tolyl) methyl phosphoramidothioate
Bayer 37289	No information available
Bayer 37342	o,o-dimethyl o-(3,5-dimethyl-4-methyl-thiophenyl) phosphorothioate
Bayer 37343	No information available
Bayer 37344	4-(methylthio)-3,5-xylyl methylcarbamate
Bayer 38156	o-ethyl-S-p-methylphenyl ethylphosphonodithioate
Bayer 38819	No information available
Bayer 38920	6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-3-methyl-6,8-methano-2,4-benzodioxathiepin
Bayer 41831	o,o-dimethyl-o-4-nitro-m-tolyl) phosphorothioate

Trade Name	Chemical Name or Active Ingredient
Bayer 44646	4-dimethylamino-3-tolyl N-methyl-carbamate
Bayer 46676	o-ethyl-o-2-ethylthio-4-methyl-6-pyrimidyl ethylphosphonothioate
Bayer 47940	o,o-dimethyl o-(3-chloro-4-cyanophenyl)-thionophosphate
Bayer 52957	o,o-diethyl o-5-chlorobenzisoxazolyl-3-phosphorothioate
Baygon®	o-isopropoxyphenyl methyl carbamate
Baytex®	See Bayer 29493
Ben Venue #35	No information available
Ben Venue #3835	No information available
Ben Venue #52	No information available
Ben Venue #54	No information available
BHC (HCK, Hexyclan)	1,2,3,4,5,6-hexachloro-cyclohexane (benzene hexachloride)
Bidrin®	3-(dimethoxyphosphinyloxy)-N,N,dimethyl-cis-crotonamide
Bomyl®	Dimethyl-1,3-di(carbomethoxy)-1-propen-2yl phosphate
Borate	Boron trioxide
BP 1002	No information available
Buramine	Crude N-mono-n-butyl urea
C 56	Hexachlorocyclopentadiene
C 2059	n-(3-trifluoro-methylphenyl) n',n'-dimethylurea
C8514	No information available
Camphene	2,2-dimethyl-3-methylenenorbornane
Captan (Orthocide®)	n-trichloromethylthio-4-cyclohexene-1,2-dicarboximide
Carbaryl (Sevin®)	1-naphthyl-N-methyl-carbamate
Carbophenothion (Trithion®)	S-{[(p-chlorophenyl)thio]methyl}o,o-diethyl phosphorodithioate
Casoron®	See Dichlobenil
Catechol	o-dihydroxybenzene
Cela S-1942	o,o-dimethyl o-(2,5-dichloro-4-bromophenyl) thionophosphate
Cela S-2225	o,o-diethyl o-(2,5-dichloro-4-bromophenyl) thionophosphate
Ceresan	Ethylmercuric chloride
Chemagro 4497	No information available
Chem Bam	See Nabam
Chem-Fish Special	Rotenone
Chem Mite	Xylene, p-chlorophenol, p-chlorobenzene sulphonate, and rotenone

Trade Name	Chemical Name or Active Ingredient
Chem Sen	Sodium arsenite
Chlordane (Octachlor®, Octa-Klor®, Chlordan, Velsicol 1068®)	1,2,3,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-4,7 methanoindene
Chlorea	Sodium chlorate, sodium metholate, and 3-(p-chlorophenyl)-1,1-dimethylurea)
Chloretone	Trichloro-tert-butyl alcohol
Chlorobenzilate	Ethyl 4,4'-dichlorobenzilate
Chlorothion	o,o-dimethyl o-(3-chloro-4-nitrophenyl) phosphorothioate
Chloroxuron (Tenoran®)	N'-(4-chlorophenoxy) phenyl N,N-dimethylurea
Chlorox	Sodium hypochlorite
CIPC	Isopropyl N-(3-chlorophenyl)-carbamate
Cleanosol	No information available
CMU	See Monuron
Conco LCP-12	No information available
Co-Ral®	o,o-diethyl o-3-chloro-4-methyl-1-oxo-2H-1-benzopyran-7-yl phosphorothioate
Crop Rider	No information available
Cryolite	Sodium aluminofluoride
Cube root	See Rotenone
Cumate	50% active copper salt of zimate
Cyanamid 12009	No information available
Cycloheximide (Actidione®)	3-[2-(3,5-dimethyl-2-oxycyclohexyl)-2-hydroxyethyl] glutarimide
Cygon	See Dimethoate
Dacthal®	Dimethyl ester of tetrachloroterephthalic acid
Dalapon	2,2-dichloropropionic acid
DBrDT	1,1,1-trichloro-2,2-bis(p-bromophenyl) ethane
DDD	See TDE
DDE	Dichlorodiphenyl dichloroethylene
DDT (Anofex®, Dinocide®, Gesapon®, Cesarex®, Gesarol®, Guesapon®, Guesarol®, Gyron®, Ixodex®, Neocid®, Zerdane, DND, GNB, GNB-A	α-bis (p-chlorophenyl) B,B,B-trichloroethane
DDVP (Dichlorvos, Vapona®)	o,o-dimethyl-o-2,2-dichlorovinyl phosphate
Dead X	No information available
Deet (Delphene®, Meta-delphene®)	N,N-diethyl-m-toluamide
DEF®	S,S,S-Tributylphosphorotrithioate
Dekafos®	3-pentadecylphenol o,o-diethylthionophosphate
Delnav®	See Dioxathion
Delrad	Dehydroabiethylamine acetate

Trade Name	Chemical Name or Active Ingredient
Demeton (Systox®, Bayer 8173, Isosystov®)	Mixture of o,o-diethyl o-2-(ethylthio) ethyl phosphorothioate and o,o-diethyl S-2 (ethylthio) ethyl phosphorothioate
Dermol	No information available
Derris	See Rotenone
Dexon®	p-dimethylaminobenzenediazo sodium sulfonate
Diazinon (Basudin®)	o,o-diethyl o-(2-isopropyl 4-methyl-6-pyrimidyl) phosphorothioate
Dibrom®	See Naled
Dicamba (Banvel D®, Velsicol)	3,6-dichloro-o-anisic acid 1
Dicapthon	O-(2-chloro-4-nitrophenyl) o,o-dimethyl phosphorothioate
Dichlobenil (Casoron®)	2,6-dichlorobenzonitrile
Dichlone (Phygon®)	2,3-dichloro-1,4-naphthoquinone
Dichlorvos	See DDVP
Dicofol (Kelthane®)	4,4′-dichloro-α-trichloromethylbenzydrol
DIDT	DDT analogue
Dieldrin	1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo-exo-5,8-dimethanonaphthalene
Difolatan	n-(1,1,2,2-tetrachloroethylthio)-4-cyclohexene 1,2-dicarboximide
Dilan	(A mixture of Bulan® [2-nitro-1,1-bis(p-chlorophenyl) butane] and Prolan® [2-nitro-1,1-bis-(p-chlorophenyl) propane]
Dimecron	See Phosphamidon
Dimethoate (Fostion MM®, Cygon®, Rogar®)	o,o-dimethyl S-(N-methylcarbamoyl-methyl) phosphorodithioate
Dimethrin	2,4-dimethylbenzyl 2,2-dimethyl-3-(2-methylpropenyl) cyclopropane carboxylate
Dimetilan®	2-dimethylcarbamyl-3-methylpyrazolyl-(5)-dimethylcarbamate
Dinitrocresol (Sinox®, Elgetal®)	4,6-dinitro-o-cresol
Dioxathion (Delnav®, Navadel®, Hercules 528)	2,3-p-dioxane 5, S-bis-(o,o-diethyl-phosphorodithioate)
Diphenamid (Dymid®)	n,n-dimethyl 2,2-diphenylacetamide
Dipterex®	See Trichlorofon
Diquat (Reglone®, FB/2®)	1,1′-ethylene-2,2′-dipyridinium dibromide
Disulfoton (Di-System®, Dithiosystox®, Frumin Al®, Solvirex®, Frumin G®)	o,o-diethyl S-2-(ethylthio) ethyl phosphorodithioate
Di-Syston	See Disulfoton
Dithane D-14®	See Nabam
Diuron (Karmex®, Marmer®)	3-(3,4-dichlorophenyl)-1,1-dimethylurea

Trade Name	Chemical Name or Active Ingredient
Dow K-6882	o-ethyl o-(2,4,5-trichlorophenyl) methyl phosphoramidothioate
Dowacide	Sodium 2,2-dichloropropionate
DPT	DDT analogue
Drummer	No information available
Dursban®	o,o-diethyl o-3,5,6-trichloro-2-pyridyl phosphorothioate
DVP-iodine	No information available
Dylox®	See Trichlorofon
Dymid	See diphenamid
EDB	1,2-Dibromoethane
Endosulfan (Thiodan®, Malix®)	6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,3,4-benzodioxathiepin 3-oxide
Endothall (Endothal®)	7-oxabicyclo-[2.2.1] -heptane-2,3-dicarboxylic acid
Endrin	1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo-endo-5,8-dimethanonaphthalene
EPN	o-ethyl o,p-nitrophenyl phenylphosphonothioate
Eptam®	S-ethyl di-N,N-propylthiocarbamate
Erbon (Baron®)	2-(2,4,5-trichlorophenoxy) ethyl-2,2-dichloropropionate
Essolvene	No information available
Esteron 99®	Propylene glycol butyl ether esters of 2,4-D
Ethion (Nialate®, Niagaia®)	o,o,o',o'-tetraethyl-S,S'-methylene bis-phosphorodithioate
Exalgae	Quaternary ammonium compounds
Fairfield 279	No information available
Fairfield OT 60-6	No information available
F-98	See Acrolein
Fenac	2,3,6-trichlorophenyl-acetic acid
Fenthion	See Bayer 29493
Fenuron TCA (Urab®)	3-phenyl-1,1-dimethylurea trichloroacetate
Ferbam (Fermate®)	See Ferbam
Flagyl	1-(2-hydroxyethyl)-2-methyl-5-nitroimidazole
Folidol®	See Parathion
Folithion®	o,o-dimethyl o-(4-nitro-m-tolyl) phosphorothioate
Forron	2,3,5-trichlorophenoxyacetic acid propylene glycol butyl ether esters
Fostion	See Dimethoate
Furazolidone	3-(5-nitrofurfurylideneamino)-2-oxazolidinone
Furoxone	N-5-nitro-2-furfurylidene-3-amino-2-oxazolidone

Trade Name	Chemical Name or Active Ingredient
G 27365	No information available
G 28029	See Phencapton
G 30493	o,o-dimethyl S-(3,4-dichlorophenylthio) methyl phosphorodithioate
G 30494	See Methyl phencapton
Gamlen CW	No information available
Gamlen D	No information available
Gamlen OSR	No information available
Gammexane®	See Lindane
Gamosol Solvent D	No information available
Garlon®	50.8% Dalapon and 7.7% 2-(2,4,5-trichlorophenoxy) propionic acid, propylene glycol butyl esters
GC-3582	1-(2,5-dichlorophenyl)-2,2-dichlorovinyl diethyl phosphate
GC-3583	2-chloro-1-(2,5-dichlorophenyl)-vinyl diethyl phosphate
GC-3707	dimethyl-1,3-di(carbomethoxy)-1-propen-2yl phosphate
GC-4072	Diethyl-1-(2,4-dichlorophenyl)-2-chlorovinyl phosphate
GC-9160	δ-(5-hydroxy-1,2,3,4,6,7,8,9,10,10-decachloro-pentacyclo decyl) ethyl levulinate
GC-9879	α-(diethoxyphosphinothioylthio) γ-butyrolacetone
GS-12968	o,o-dimethyl-S [5-ethoxy-1,3,4-thiodiazol-2(3H)-onyl-(3)-methyl] -dithiophosphate
GS-13005	o,o-dimethyl-S-[2-methoxy-1,3,4-thiodiazol-5(4H)-onyl-(4)-methyl] -dithiophosphate
Guthion®	o,o-dimethyl S [4-oxo-1,2,3-benzotriazin-3(4H)-ylmethyl] phosphorodithioate
Gutoxon	See Guthion
HCK	See BHC
Hept	Hexaethyl tetraphosphate
Heptachlor (Velsicol® 104)	1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,7-endo-methanoindene
Hercules 528	See Dioxathion
Hercules 3895 G	2,2-bis(ethylthio)-vinyl diethylphosphate
Hercules 7175	1-(chloro-2-norbornyl)-3,3-dimethylurea
Hercules 7531	No information available
Hexyclan	See BHC
Hyamine 1622	p-diisobutyl phenoxy ethoxy dimethyl benzyl ammonium chloride

Trade Name	Chemical Name or Active Ingredient
Hyamine 2389	40% Methyl dodecyl benzyl trimethyl ammonium chloride and 10% methyl xylene bis-trimethyl ammonium chloride
Hydram®	See Molinate
Hydrothal	Potassium salt of 2,2,4,5 trichlorophenoxy) propionic acid and di-(N,N dimethylalkylamine) salt of 3,6 endoxo-hexahydrophthalic acid
Ibcol	No information available
Imidan®	o,o-dimethyl-S-phthalimidomethyl phosphorodithioate
Inverton®	No information available
Iodophor	Iodine formulated with solubilizing agents
IPC	Isopropyl-N-phenylcarbamate
Isobenzan (SD-4402)	1,3,4,5,6,7,8,8-octachloro-3a,4,7,7a-tetrahydro-4,7-methanophthalon
Isodrin	1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4-endo,endo-5,8-dimethanonaphthalene
Isolan	Dimethyl 5-(1-isopropyl-3-methyl-pyrazolyl) carbamate
Isotex	No information available
K 6882	No information available
Karmex®	See Diuron
Kelthane®	See Dicofol
Kepone®	Decachlorooctahydro-1,3,4-methano-2H-cyclobuta-[cd]-pentalen-2-one
Korlan®	See Ronnel
Kuramine	Amine formulation of 2-(2,4,5-trichlorophenoxy) propionic acid
Kurosal	No information available
Kurosal G	No information available
Kurosal SL	No information available
Kuron®	Propylene glycol butyl ether esters of Silvex
Kyro-Eo	No information available
Lethane 384	2-(2-butoxyethoxy) ethyl thiocyanate
Lexone	γ-isomer of benzene hexachloride
Lignasan	Ethylmercury phosphate
Lindane (Gammexane®)	γ-isomer of 1,2,3,4,5,6-hexachlorocyclohexane
M-502	No information available
M-1499	No information available
M-1500	2,2,4,5-trichlorophenoxy propionic acid
M-1845	No information available
Malaoxon	O_2 analogue of Malathion

Trade Name	Chemical Name or Active Ingredient
Malamar-50	50% Malathion
Malathion	S-[1,2-bis-(ethoxycarbonyl)ethyl] o,o-dimethyl phosphorodithioate
Manzate®	See Maneb
Maneb (Manzate®, Dithane®)	Ethylene-bis-dithiocarbamate manganese
MCP	See MCPA
MCPA (Agroxone®, Methoxone®)	4-chloro-2-methyl phenoxy acetic acid
MCPB	4-chloro-2-methyl phenoxy butyric acid
Metasystox®	See Methyl Demeton
Methoxychlor	1,1,1-trichloro-2,2-bis-(p-methoxy-phenyl) ethane
Methyl Demeton (Metasystox®)	Mixture of o,o-dimethyl-o-2-(ethylthio) ethyl phosphorothioate (A) and o,o-dimethyl S-2(ethylthio) ethyl phosphorothioate (B)
Methyl parathion (DAEF®, Nitrox®, Nitrox 80®)	o,o-dimethyl o,p-nitrophenyl phosphorothioate
Methyl phencapton	o,o-dimethyl S-(2,5-dichlorophenylthio) methyl phosphorodithioate
Methyl trithion®	o,o-dimethyl s-(p-chlorophenylthio) methyl phosphorodithioate
MGA Evergreen	No information available
MGA 6103	No information available
MGA 6243	No information available
Mirex	Dodecachlorooctahydro-1,3,4-methano-2H-cyclobuta-[dc]-pentalene
Molinate (Hydram®, Ordram®)	S-ethyl hexahydro-1H-azepine-1-carbothioate
Monuron (Telvar®, CMU)	3-(p-chlorophenyl)-1,1-dimethylurea
Monuron-TCA (Urox®)	[3(p-chlorophenyl)-1,1-dimethylurea trichloracetate]
MS 222	No information available
N 2404	o-isopropyl-o-(2-chloro-4-nitrophenyl)-ethylphosphonothioate
N 2788	o-ethyl-S-p-tolyl-ethylphosphonodithioate
N 2790	o-ethyl-S-phenyl-ethylphosphonodithioate
Nabam (Chem Ban, Dithane D-14®, Parzate®)	Disodium ethylene bis-dithiocarbamate
Naled (Dibrom®)	1,2-dibromo-2,2-dichloroethyl dimethyl phosphate
Neburon	3-(3,4-dichlorophenyl)-1-methyl-1-n-butylurea
Neguvon®	See Trichlorofon
Nemagon®	1,2-dibromo-3-chloropropane
Neotran®	bis(p-chlorophenoxy) methane
Nigrosine	Aniline black
Noxfish®	Rotenone
N-serve	2-chloro-6-(trichloromethyl) pyridine

Trade Name	Chemical Name or Active Ingredient
Nytron®	25% or more ammonium content
Omazine®	Cupric dihydrazinium sulfate
Octachlor	See Chlordane
Octalene	See Aldrin
OMPA	See Schradan
OMS-3	No information available
OMS-44	o-3,5-dichloro-4-methylthiophenyl) o,o-dimethyl phosphorothioate
OMS-115	No information available
OMS-144	No information available
OMS-315	S-p-chlorophenyl o,o-dimethyl phosphorodithioate
OMS-437	Toluene-α,α-dithiol bis-(o,o-dimethyl phosphorodithioate)
OMS-595	2-chloro-1-(2,4,5-trichlorophenyl) vinyl dimethyl phosphate
OMS-648	o,o-diethyl-(5-chlorobenzisoxazolyl-3) phosphorothioate
OMS-658	o-(4-bromo-2,5-dichlorophenyl) o,o-dimethyl phosphorothioate
OMS-659	o-(4-bromo-2,5-dichlorophenyl) o,o-diethyl phosphorothioate
OMS-711	2-chloro-1-(2,5-dichlorophenyl) vinyl dimethyl phosphate
OMS-712	2-chloro-1-(2,4-dichlorophenyl) vinyl dimethyl phosphate
OMS-754	S-(o-chlorophenyl) o,o-dimethyl phosphorodithioate
OMS-868	No information available
Ordram®	See Molinate
Ortho 5305	3-sec-butylphenyl-N-methyl carbamate
Ortho 5353	3-sec-amylphenyl-N-methyl carbema
Ortho 5655	3-sec-butyl 6-chlorophenyl N-methyl carbamate
Ortho MH30	58% diethanolamine salt of 1,2-dihydro-pyridazine-3,6-dione and 30% maleic hydroxide
Orthocide	See Captan
Ovex (Ovochlor, Ovotran®, Estonmite®, DOW K-6451®)	p-chlorophenyl, p-chlorobenzene sulfonate
Oxydemetonmethyl (Meta-Systox®)	No information available
Paramar-50	50% Parathion
Para-Oxon (Mintacol®)	o,o-diethyl-o,p-nitrophenyl phorphate
Paraquat	1,1'-dimethyl-4,4'-dipyridylium cation
Parathion (Folidol®, Thiophos®, Niran®, Alkron®, Phodiatox®)	o,o-diethyl-o,p-nitrophenyl phosphorothioate

Trade Name	Chemical Name or Active Ingredient
Parzate®	See Nabam
Pebulate (Tillam®)	S-propylbutylethylthiocarbamate
Perthane®	1,1-dichloro-2,2-bis-(p-ethylphenyl) ethane
Phencapton (Phenkaptone®)	o,o-diethyl-S-(2,5-dichlorophenylthiomethyl) phosphorodithioate
Phorate (Thimet®)	o,o-diethyl-S-(ethylthio) methyl phosphorodithioate
Phosdrin®	2-carbomethoxy-1-propen-2yl dimethyl phosphate
Phosphamidon (Dimecron®)	1-chloro-diethyl-carbamoyl-1-1-propen-2yl dimethyl phosphate
Phygon®	See Dichlone
Picloram (Tordon®)	4-amino-3,5,6-trichloro-picolinic acid
P.M.A. (PMAC, PMAS)	Phenylmercuric acetate
Polyclens	No information available
Polysan	No information available
Prometone	2-methoxy-4,6-bis(isopropylamino)-2-triazine
Prometryne	2-methylmercapto-4,6-bis(isopropylamino)-3-triazine
Pro-noxfish	Rotenone
Propanil (Rogue®, Stam F-34®)	3',4'-dichloropropion-anilide
Pyramat	2-n-propyl-4-pyridinyl-(6)-dimethyl-carbamate
Pyrethrin	See Barthrin
Rivanol	6,9-diamino-2-ethoxyacridine
Roccal®	Alkyl dimethyl benzyl ammonium chloride
Rogue®	See Propanil
Ronnel (Korlan®, Trolene®, Viozene®, Dow ET-57®, Dow ET-14®)	Dimethyl 2,4,5-trichlorophenyl phosphorothioate
Rotenone	Decrin
Ruelene®	4-tert-butyl-2-chlorophenyl methyl methylphosphoromidite
Ryania (Ryanodine)	Ground stemwood of *Ryania speciosa*
Sarin	Isoproporymethyl phosphoryl fluoride
Schradan (OMPA, Pestox III®, Pestox 3®)	Octamethylpyrophosphoramide
SD 4402	See Isobenzan
SD 7727	2,4-dichlorophenyl methanesulfonate
SD 7772	Phosphoric acid, 2-chloro-1-(2,5-dichlorophenyl) vinyl dimethyl ester
SD 8211	Phosphoric acid, 2-chloro-1-(2,5-dichlorophenyl) vinyl dimethyl ester
SD 8447 (OMS-595)	2-chloro-1-(2,4,5-trichlorophenyl) vinyl dimethyl phosphate
SD 8530	Carbamic acid, methyl-3,4,5-trimethyl phenyl ester

Trade Name	Chemical Name or Active Ingredient
SD 8803	Phosphorothioic acid, o-[2-chloro-1-(2,4-dichlorophenyl) vinyl]-o,o-diethyl ester
SD 9129	Dimethyl phosphate of 3-hydroxy-N-methyl-cis-crotonimide
Separan	No information available
Sernyl	1-(1-phenylcyclohexyl) piperidine hydrochloride
Servin	No information available
Sevin®	See Carbaryl
Shadran	Octamethylpyrophosphoramide
Shell 4072	No information available
Shell SD-7438	Toluene-α, α-dithiol bis-(o,o-dimethyl phosphorodithioate)
Shell SD-7961	No information available
Shell SD-8447	2-chloro-1-(2,4,5-trichlorophenyl) vinyl dimethyl phosphate
Shell SD-8448	No information available
Shell SD-9129	Dimethyl phosphate of 3-hydroxy-N-methyl-cis-crotonimide
Silvex	2-(2,4,5-trichlorophenoxy) propionic acid
Simazine (Gesatop®)	2-chloro-4,6-bis-(ethylamino)-s-triazine
Sinox General	50% dinitro-o-secondary butyl and 10% dinitro-o-secondary amyl butyl phenol
Slickgone 1	No information available
Slickgone 2	No information available
Slix	No information available
Sovicide	No information available
Stam F-34®	See Propanil
Stauffer N-2790	No information available
Stauffer R-1910	Ethyl-N,N-diisobutyl thiocarbamate
Stauffer R-4461	No information available
Stauffer R-5092	No information available
Steramine	p-diisobutyl phenoxy ethoxy ethyl dimethyl benzyl ammonium chloride monohydrate
Strobane® (Strobane AC-14®)	Terpene polychlorinates
Styrene	Phenyl ethylene
Sulfotepp (Dithione®, Bladafume®)	o,o,o,o-tetraethyl dithipyrophosphate
Swep	Methyl 3,4-dichlorocarbanilate
Systox®	See Demeton
TBA	2,3,6-trichlorobenzoic acid
TCA	Trichloroacetic acid
TD 47	Di-n,n-dimethylcocoamine salt of 3,6 endoxohexahydrophthalic acid

Trade Name	Chemical Name or Active Ingredient
TD 72	No information available
TD 440	No information available
TD 497	Amine salt of 3,6-endoxohexahydrophthalic acid
TDE (DDD, Rhothane®)	2,2-bis-(p-chlorophenyl)-1,1-dichloroethane
Telvar®	See Monuron
Tenoran	See Chloroxuron
Trithion	See Carbophenothion
Telodrin	82% isobornyl thiocyanoacetate
TEPP (Bladan®, Tetron®, HETP, TEP)	Tetraethyl pyrophosphate
TFM	3-trifluoromethyl-4-nitrophenol
Thanite®	Isobornyl thiocyanoacetate
Tillam®	See Pebulate
Thimet®	See Phorate
Thiodan®	See Endosulfan
Thionazin (Zinophos)	o,o-diethyl-o-2-pyrazinyl phosphorothioate
Thiram (Nomersan®, Pomasol®)	Tetramethylthiuram disulfide
Tiguvon	o,o-dimethyl-o-[4-(methylthio)-m-tolyl] phosphorothioate
Tordon®	See Picloram
Tordon 101®	39.6% triisopropanol-amine salt of 2,4-D, and 10.2% picloram triisopropylamine salt
Toxaphene (Phenocide®, Phenatox®)	Chlorinated camphene
2,4,5TP	No information available
Treflan®	See Trifluralin
Trefmid	No information available
Trichlorofon (Dipterex®, Dylox®, Neguvon®, Tugon®)	o,o-dimethyl-(1-hydroxy-2,2,2-trichloroethyl) phosphate
Tricon	No information available
Trifluralin (Treflan®)	α,α,α-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine
Trithion®	See Carbophenothion
Trolene®	See Ronnel
TV-1096	Lg-threo-2-(5-nitro-2-furyl)-5-(p-nitrophenyl)-2-oxazoline-4-methanol
UC 8305	p-chloro-2,4-dioxa-5-methyl-p-thiono-3-phosphabicyclo-(4.4.0)-decane
UC 10854	m-isopropylphenyl N-methycarbamate
UC 19786	2-sec butyl-4,6-dinitrophenyl isopropyl-carbonate
UC 20047	3-chloro-6-cyano-2-norbornanone o(methyl-carbamoyl) oxime
UC 21149	2-methyl-2-(methylthio) propionaldehyde o-methyl-carbamoyl) oxime

Trade Name	Chemical Name or Active Ingredient
UC 21427	No information available
Urox®	See Monuron-TCA
Vancide 51Z	Mixture of zinc dimethyldithiocarbamate and zinc 2-mercaptobenzothiazole
Vapona®	See DDVP
Velsicol	See Dicamba
Velsicol 1068	See Chlordane
Veon-100	Dimethylamine salt of 2-4 dichlorophenoxyacetic acid-dimethylamine salt-2,4,5-trichlorophenoxy-acetic acid
Vernolate (Vernam®)	S-propyl dipropylthiocarbamate
Vernam®	See Vernolate
Versene	Sodium acetate
Versenol	A series of chelating agents
Vis-ko Stop-Mold "B"	54% sodium-o-phenylphenate
Weedar MCP	No information available
Weedex	41% sodium metarsenite
Weed Rap	20(2-ethyl hexyl ester of 2,4-dichlorophenoxy-acetic acid)
Zectran®	4-dimethylamino-3,5-xylyl n-methyl-carbamate
Zerlate®	See Ziram
Zinophos	See Thionazin
Ziram (Zerlate®, Milbam®, Fuklasin®)	Zinc dimethyldithiocarbamate
Zytron®	o-(2,4-dichlorophenyl)o-methyl isopropylphos-phoramidothioate

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